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THE FIRST AND LAST ESSENTIAL STEP IN COMBATING THE BOLL WEEVIL[1]

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The Problem of Weevil Control

Statement of the Problem.—During the past fifteen years the Mexican cotton boll weevil has spread throughout Texas, northward to about the middle of Oklahoma and southeastward from that region through southern Arkansas nearly to the Mississippi River, then southward through Louisiana, covering practically the entire western portion of the state and even spreading across the river into a few of the southwestern counties of Mississippi. Nothing seems likely to permanently check its eastward movement throughout the other cotton-growing states. It now infests practically one half of the cotton-growing area and is doing damage which can hardly be estimated at less than $25,000,000 a year.

To the entomologist the practical problem is that of reducing the injury within the infested area to the smallest possible amount and to restrict the spread of the pest so far as it may be within human power to do so by the enforcement of quarantine regulations to prevent its being carried long distances into uninfested territory by commercial agencies.

Brief Survey of the Results of Investigational Work on Control

Factors in Natural Control.—These factors are, by their very nature, inconstant and unreliable, although they may often be of prime importance and are apparently of generally increasing value. The uncertainty of climatic factors which are sometimes of greater im-

[1] Read before the Association of Economic Entomologists, at Chicago, Ill., December, 1907.

portance than any others need only be mentioned as an illustration of this class. The general difficulty is that we cannot tell what their effect may be until it becomes too late to take proper advantage of the conditions which they produce.

Natural enemies, both predaceous and parasitic, may also be valuable allies in the fight and every advantage possible should be taken of them, but it is simply folly for the cotton planter to sit idly by trusting nature to do all of the control work for him. However, it is certain that we would have a much more hopeless task in attempting control without the help of these natural factors and we may well study object lessons of the strongest kind, which nature frequently gives us as practical effects which man may himself, in some measure, reproduce.

Methods of Direct and Indirect Combat.—Naturally, through their general applicability to similar problems, the first recourse of the entomologist and of the planter as well is to insecticides. It is sufficient to say that "hosts" of these, both promising and otherwise, have been carefully tested and invariably found practically useless in fighting the weevil. The most promising and also widely tested of them all is Paris Green dusted on the young plants at intervals beginning before squares form, but its use has proven so constantly disappointing when applied that it has been practically abandoned by entomologists and by most planters.

The real reason for failure with Paris Green applies with equal force to all other arsenicals and to contact insecticides as well. Owing to the practical impossibility of applying it to those partially protected places where the weevils normally feed, only from one third to one half, on the average, of the adult weevils on the plants at the time of the treatment can be killed. The very long period of emergence from hibernation makes the number of weevils on the plants at one time but a very small fraction of the entire number which may survive and attack the crop. This renders frequent treatments necessary and their effectiveness is only partial at best. The immature stages cannot be reached by any insecticide, as they are surrounded constantly by several layers of vegetable tissue, and to penetrate that would require a power in the insecticide that would be fatal to the plant. Repeated applications of dry Paris Green (and of other insecticides as well) will often do more damage to the crop through its harmful effect upon the growth of the plant than would the weevils if allowed to do their worst.

No method of applying any efficient fumigant has been found applicable to a field crop like cotton. Small-scale experiments with the leading fumigants have indicated that none of them could be de-

pended upon to kill the immature stages even if they would kill the adults.

Trap rows are rendered impracticable by many considerations, but especially by the period of emergence from hibernation extending far beyond the time of any practicable delay in the planting of the main crop.

Among the multitude of machines devised, most have been designed for collecting and destroying the adults, or both adults and the infested fruit. Although some of them have been built at great expense and with the best of mechanical skill, none has yet proven superior to the practical difficulties encountered in field operation. It may be said fairly that there is not now on the market a practicable machine for combating the weevil. It is possible that the most promising device of this nature is one originated by the writer during the latter part of the season of 1907, which is now being patented by the Department of Agriculture. But this machine has not yet been tested upon a sufficiently large scale to justify its commendation for general use. However, it belongs rather to the methods of cultural control, since it combines the action of drawing the fallen, infested forms to the centers of the paths where the weevil stages will be mostly destroyed by the action of the direct sunshine, with the coincident cultivation of the crop.

The constant failures experienced in applying any direct method of attack have made it necessary that primary reliance for the control of the weevil should be placed upon indirect methods of cultural control which have as constantly given more encouraging results. It is now more than ten years since Dr. L. O. Howard first suggested the importance of cultural methods in fighting this insect. Ever since that time in all of the extensive work which has been carried on by the agents of the Bureau of Entomology, particular attention has been given to this phase of the problem. The general recommendations worked out by the agents of the Bureau have been frequently repeated in various publications and are now widely known. They have also been demonstrated in a practical way through the Demonstration Farm work carried on by the Bureau of Plant Industry. There is evident a large increase in the proportion of the most progressive planters who have adopted part, if not all, of these recommendations. There can be no adequate measurement of the value of the results of this work already obtained and it is equally certain that the possible good results are only beginning to be realized.

In the best sense of the word, the methods *advocated for the cultural control of the weevil constitute a* "system." The various steps

are so interdependent that securing the full benefit from any one of them involves the adoption of many of the others. A careful consideration of each step, both as to its independent and interdependent effectiveness seems to justify the broad general assertion that the early fall destruction of its food-supply—cotton—may reasonably be called, as it has frequently been, "the most important step in the cultural system of controlling the weevil." The exhaustive studies which have been made by the field agents of the Bureau on all phases of the life and seasonal histories and upon natural and artificial control of the weevil indicate that the few weeks which may intervene between the maturity of the bulk of the crop and the time that is most favorable for the weevils to enter hibernation constitutes the strategic period for largely reducing the number of weevils which may survive hibernation and attack the crop of the following season. The application of all other steps in the system recommended is designed primarily and ultimately to render this period as long as possible and to thereby increase the practical possibility of the general adoption of this step as the final and most important thing in the work of each season, and thus open the way for the most successful results with the culture of a cotton crop with the minimum of weevil injury during the following year.

The most convincing experiments showing definitely the possibilities of and urgent necessity for the adoption of this plan and also a large-scale field demonstration of the great, practical benefit obtainable in a community by its general adoption, have been accomplished during the past year. A full account of the experimental work is being published by the Bureau of Entomology under the title of "Hibernation of the Cotton Boll Weevil" by Mr. W. W. Yothers and the writer.

Having given but a very brief and partial view of the general problem which the presence of the boll weevil inevitably presents and of the general results of the investigation to secure feasible methods of control, the writer would add a brief summary of the data which support the conclusions stated as to the essential value of stalk destruction. For the sake of brevity much important work cannot be mentioned here. The extensive hibernation experiments of 1906-'07 will alone be considered, although mention may be made of the general results of other investigations when needed for comparisons.

Principal Data Indicating the Importance of Stalk Destruction

Hibernation Work of 1906-'07.—Some knowledge of the general plan and purpose of this work seems essential to a clear understanding

of its value and a correct interpretation of the results observed. Three localities, Dallas, Calvert and Victoria, Texas, were selected for experimental work, as these represented in a general way the northern, central and southern sections of the state, and considerable work of a similar nature had been done at each place which might serve as a check or for comparison. At each place was erected a cage 20 x 50 feet and 6½ feet high, covered with 14-mesh, galvanized wire screening and having cross-partitions so as to form ten sections, each having a ground area of 100 square feet. The three localities offered a considerable range in geographical and climatic conditions. It was planned to provide similar shelter conditions in corresponding sections and to enclose weevils in each section upon as nearly the same date in each locality as might be possible. The weevils used were collected in the immediate locality and from 1,000 to 4,000 were placed in each section, making a total of over 75,000 in the three cages. Observations were made at intervals, from the time weevils were placed in the cage until the beginning of the general emergence movement in the spring, and daily thereafter. Suitable and reliable data as to climatic conditions were secured by providing standard types of weather bureau instruments in a shelter erected beside the cage in each locality. Temperature, rainfall, humidity and other records were thus kept throughout the period covered by the experiments. In this way it was anticipated that data might be obtained bearing especially upon the following points:

1. The effect of the time of entrance into hibernation upon the survival of weevils. In the first experiments either entrance upon hibernation or starvation was forced by the destruction of the food supply. The geographical range would naturally increase the interval between the beginning of the experiment and the time when weevils would naturally enter hibernation at each locality.

2. The effect which the complete destruction of the food supply at varying dates might have upon the success of hibernation. For these experiments the shelter conditions were made as uniform and as favorable as it was possible to make them in the different localities. It was hoped by these tests to determine the minimum interval which must elapse between the destruction of food and the successful hibernation of the weevils.

3. To determine the effect of exceptionally favorable and unfavorable conditions of shelter upon the successful hibernation of weevils placed in the corresponding sections upon the same date in each locality. It was intended that the shelter conditions provided should be so exaggerated as to represent the extremes of conditions which might naturally occur in or around the fields.

4. To determine the effect which varying depths and classes of shelter might exert upon the success of hibernation and also upon the time of beginning and the range in the period of emergence from hibernation.

5. To test the power of adaptation to climatic variations by bringing weevils from widely separated localities and hibernating them for comparison with weevils collected at Dallas. In each section food and shelter conditions were to be similar.

6. To determine upon a large scale and in widely separated localities and under various conditions of shelter the proportion of weevils entering hibernation which might survive.

7. To determine the relation of climatic conditions to the emergence period in each locality.

8. To determine the longevity of hibernated weevils after emergence both with and without food.

In the following table are summarized the principal points relating to the installation of the experiments for this season:

Table I. Installation of hibernation experiments, 1906-1907

No. of Section.	Date of Starting Experiments, 1906.			Character of Shelter Supplied.	Conditions as to Food Supply.
	Dallas.	Calvert.	Victoria.		
1	Oct. 13	Oct. 13	Oct. 25	Leaves and grass 4-5 in. deep.	All cotton removed after two days.
4	Oct. 16	Oct. 19	Oct. 25	do.	Stalks cut and left.
2	Oct. 19	Nov. 26	Oct. 28	do.	Food removed after two days.
7	Oct. 25	Oct. 25	Nov. 6	Spanish moss hung around top of cage. Loose bark on ground.	Food present; cut and allowed to dry.
8	Oct. 31	Oct. 31	Nov. 10	Leaves and grass 4-5 in. deep.	Food removed after two days.
5	Nov. 6	Nov. 5	Nov. 14	do.	Cotton cut and allowed to remain and dry.
3	Nov. 12	Nov. 14	Nov. 21	Leaves and grass two inches deep.	do.
9	Nov. 12	Nov. 12	Nov. 21	Leaves and grass ten inches deep.	do.
6	Nov. 28	Nov. 25	Nov. 28	Ground absolutely bare.	No food supply.
10	Dec. 6 and 10	Dec. 3	Nov. 29	Three bushels, probably, infested bolls on surface of half of cage and 3 bushels buried under 2 inches dirt in other half.	do.

Having now followed the beginning of the experiments, it is in order to note the climatic conditions prevailing throughout them. Temperature records were the most abnormal and also the most significant and therefore only those are given in Table II.

Table II. Mean monthly temperatures and departures from normals at Dallas, Calvert and Victoria, Texas, November, 1906, to June, 1907, inclusive

Locality, Texas.	November.		December.		January, 1907.		February.*	
	Monthly mean °F.	Departure °F.	Monthly mean °F.	Departure °F.	Monthly mean °F.	Departure °F.	Monthly mean °F.	Departure °F.
Dallas	54.3	−0.6	51.6	+3.8	53.4	+8.5	51.2	+6.6
Calvert	59.1	+0.1	56.8	+4.1	59.8	+9.6	54.8	+2.8
Victoria	62.9	−1.8	59.2	+1.4	63.4	+9.8	60.2	+6.2
	March.		April.		May.		June.	
Dallas	66.7	+11.1	61.4	−4.2	65.8	−7.7	78.8	−1.9
Calvert	70.0	+ 9.2	62.2	−5.9	66.6	−7.3	76.6	−4.4
Victoria	72.4	+ 9.7	69.4	−3.3	73.0	−5.0	81.6	−0.6

The columns giving the departures from normals are particularly significant as showing the very unusually warm winter and early spring and the exceptionally cold period following. It was actually much warmer in March throughout Texas than during April and May. These facts account for the unusually large percentages of survival, the remarkably early beginning of emergence and the long duration of the emergence period. At no time during the winter was hibernation complete anywhere in Texas. Weevils were active both in the cages and in the fields. This has never happened before, except rarely in extreme southern Texas.

Next in order will be the consideration of the general results of the observations upon the survival of weevils.

Table III. Summary of Emergence records from hibernation experiments, 1906-1907

Locality, Texas.	No. of Weevils put in Cages.	No. of Weevils as basis for determining per cent. of Survival.[1]	No. Weevils Emerged.	Per cent. of Survival.
Dallas	32,439	30,864	3,464	11.22
Calvert	20,430	19,408	1,842	9.49
Victoria	23,645	22,463	3,026	13.47
Totals	76,514	72,735	8,332	11.45

It is probable that 11.5 is the largest percentage that has ever survived in Texas considering so large an area. In the experiments of

[1]Basis for computing percentage of emergence is 5% less than the number placed in the cage to allow for the escape of some through the wire.

the preceding season at Keachie, La., and Dallas, Texas, among 35,900 weevils, the average survival was only 2.18 per cent. The emergence movement began on March 22 and continued until June 28, 1906. These are unquestionably closer to the normal facts regarding emergence than are the figures shown in 1907. We have thus in two seasons a range in percentage of survival of from 2 to 11 per cent and in emergence from February 15 to the end of June. These facts emphasize very strongly the importance of reducing the number of weevils entering hibernation.

In order to make the following facts represent general conditions and avoid the possibility of being misled in our conclusions by the variations which might reasonably occur in a single experiment, we shall present the data in groups of experiments and base our conclusions upon the average results shown by the totals and average percentages for each group. The chronological significance of the data may be most clearly shown by grouping the records for those localities at which experiments were started upon the same or approximate dates. The shelter and food conditions represented in each group are therefore fairly averaged and the time at which the experiments were started becomes the most significant factor in each group. The desired comparisons can be most briefly shown by tabular arrangement.

In Table IV it may be seen that averaging all localities at which weevils were started upon approximately the same date, there is a most striking increase in successful survival from the middle of October to the middle of November. In the interval of eleven days from October 14 to 25 the percentage of survival practically doubled. During the next ten days the percentage again doubled and a corresponding increase is observable between November 5 and 14. After that time hibernation might have been successful for practically the maximum possible proportion of weevils. The first freeze occurred on November 18. The facts shown may appear more emphatic if stated in another way. Under otherwise similar average conditions, the chances for survival for weevils in Texas in 1907 were: On October 15, one; October 25, two; November 5, four; November 15, six. These facts make it plainly evident that from October 15 to November 15 constitutes the *strategic period* for attack upon the boll weevil. The data and conclusions are here given that they may be studied carefully by those who are interested to do so.

Conclusions Drawn from Data Presented

Application of Conclusions.—The method of attack which has proven most effective consists of the successive steps constituting the

Table IV. **Effect of time of entrance into hibernation, or isolation from food supply upon survival of weevils**

Date, 1906	Locality, Texas.	Section Number.	No. Weevils Present.	No. Weevils Emerged.	Per cent. of Survival.	Rank of Group in Survival.	Remarks.
Oct. 13	Dallas	1	3,800	99	2.61		
Oct. 13	Calvert	1	2,375	75	3.15		
Oct. 16	Dallas	4	2,090	85	4.07		
Totals for group		3	8,265	259	3.14	8	
Oct. 19	Calvert	4	2,375	116	4.88		
Oct. 20	Dallas	2	3,610	226	6.26		
Totals for group		2	5,985	342	5.71	7	
Oct. 24	Dallas	7	3,325	231	6.95		
Oct. 25	Calvert	7	2,375	105	4.42		
Oct. 25	Victoria	1	2,375	201	8.46		
Oct. 25	Victoria	4	2,375	105	4.42		
Totals for group		4	10,440	642	6.15	5	
Oct. 28	Victoria	2	2,389	134	5.61		
Oct. 30	Dallas	8	2,850	250	8.85		
Oct. 31	Calvert	8	2,375	63	2.65		
Totals for group		3	7,614	447	5.87	6	
Nov. 5	Dallas	5	3,135	383	12.22		
Nov. 5	Calvert	5	2,375	45	1.89		
Nov. 6	Victoria	7	2,850	674	23.65		
Totals for group		3	8,360	1,102	13.18	4	
Nov. 10	Victoria	8	2,850	362	12.70		
Nov. 12	Dallas	3	3,040	448	14.74		
Nov. 13	Dallas	9	3,040	788	25.92		
Nov. 14	Calvert	9	2,375	438	18.44		
Nov. 14	Victoria	5	2,850	449	15.86		
Nov. 15	Dallas	11	2,565	804	31.31		
Totals for group		6	16,720	3,284	19.67	2	
Nov. 21	Dallas	12	1,570	65	4.14		Brownsville Weevils.
Nov. 21	Victoria	9	2,836	374	13.19		
Nov. 21	Victoria	3	2,850	588	20.63		
Totals for group		3	7,256	1,027	14.15	3	16.91% without B. W.
Nov. 25	Calvert	6	1,425	359	25.19		
Nov. 26	Calvert	2	1,358	380	27.98		
Nov. 28	Dallas	6	975	46	4.72		(Absolutely bare ground.)
Nov. 28	Victoria	6	1,088	139	12.78		
Totals for group		3	4,846	924	19.07	1	(22% without Dallas lot.)

Cultural System. Having secured an early maturing crop, it should be picked out as soon as open, the earlier the better. If not all gathered before October first in South Texas, every effort should be put forth to clean up the fields by that time and the few late opening bolls should not be allowed to delay the immediate destruction of the stalks in some thorough manner. In the southern part of the state where sprout cotton commonly occurs, great care should be taken to destroy enough of the roots to prevent any sprouting in the spring. Clean

the fields as thoroughly as possible, including the turn-rows and along ditches and fences and under timber fringes. This thorough treatment is even more essential in south than in north Texas, although in the latter portion of the state it seems advisable.

As has been frequently pointed out, this early fall destruction prevents absolutely the further breeding of weevils and many of those partly developed in squares or bolls will not be able to mature. The late developed weevils are most liable to hibernate successfully. By destroying the most favorable shelter which the weevils that escape destruction could possibly find, the chances of their surviving the winter are greatly lessened. In a variety of ways, therefore, the actual number of weevils entering hibernation becomes very greatly reduced and the chances of the successful hibernation of those entering are correspondingly decreased. The number of weevils ready to attack the crop the following spring would, with these practices, be but a small fraction of what might otherwise be present.

The Demonstration.—That these conclusions are correct and practicable has been proven by actual field application on a large scale. At Olivia, Texas, in the fall of 1906, about twenty planters on adjoining farms were persuaded to enter into agreement to do this work by Mr. J. D. Mitchell. All stalks were destroyed upon an area of about 40 acres between October 1 and 10. This area was well isolated from other cotton, but had been badly infested up to that time. A check area some six miles away across a bay received the usual treatment. No special treatment was given to the Olivia tract during 1907. In spite of the fact that the survival of weevils, as has been shown, was unprecedented during this intervening winter, they did not become numerous enough to do any considerable damage to the Olivia crop, while on the check area they were exceedingly injurious. Although the Olivia crop was grown on soil that was not as rich as that in the check, it yielded more than 1,000 lbs. of seed cotton per acre, whereas the check yielded but about 300 lbs. per acre. The difference in value of these two crops was fully $20 per acre, or more than enough to pay for the land upon which the crop at Olivia was grown.

The Difficulties.—If there were no obstacles in the way of an easy adoption of these recommendations, it is not likely that the same necessity for them would exist. Any prospect for a late "top" crop" of cotton is removed by the presence of the weevils. Every experience shows that the crop must be made early. The difficulty of getting sufficient labor is great in some sections. It is evident that there is necessity for the production of an efficient machine for cotton picking to meet this need. The actual destruction of stalks may be . . .

ished in any way possible so long as the desired results are obtained. he question is not one of method but of results. More particulars to time and methods are given by Mr. W. D. Hunter in Circular of the Bureau of Entomology. It is certain that the individual opting the Cultural System may reap a large share of its benefits gardless of the lack of coöperation on the part of his neighbors, but is desirable that a strong sentiment should be fostered which shall lead to united action over considerable areas. It is to be hoped that the practical difficulties presented by the tenant system may be overcome, so that every tenant will be led (or forced if need be) to consider that his season's work is not complete until he has added this step to the harvesting of the crop. This idea would be welcomed if there could be a general understanding by landowners and tenants of the fact that fields thus treated will produce better yields, as a rule. They would be better inducements to securing a good class of tenants, and such tenants having cleared their fields in the fall would be less likely to move.

The question here presented is a vital one for the weevil-infested area. It demands not merely acquiescence, but action. The accuracy of the facts presented cannot be questioned, but each man must decide for himself as to the correctness of the conclusions. To us it appears that this statement does abundantly justify the broad, general conclusion that "the DESTRUCTION OF STALKS BY SOME EFFECTIVE METHOD AND AS LONG AS MAY BE POSSIBLE BEFORE THE NORMAL TIME FOR WEEVILS TO ENTER HIBERNATION CONSTITUTES THE MOST EFFECTIVE METHOD NOW KNOWN OF REDUCING THE SEVERITY OF THE WEEVIL ATTACK UPON THE FOLLOWING CROP AND THAT IT THEREFORE DESERVES GENERAL RECOGNITION AND ADOPTION AS THE LAST STEP IN THE TREATMENT OF EACH SEASON'S CROP AND ESSENTIALLY THE FIRST STEP ALSO IN THE PRODUCTION OF A CROP WITH THE MINIMUM WEEVIL INJURY DURING THE FOLLOWING SEASON."

Grape Blossom Midge

Cecidomyia johnsoni Sling. This species, unknown as an adult, caused exceptional injuries at Fredonia, where it destroyed 60% to 75% of the blossoms on one acre of Moore's Early grape. The work of this species has been known for years, and the familiar galled blossoms were easily found throughout the entire Chautauqua region. The work above described is undoubtedly due to exceptional conditions and is probably explainable by the blossoms being in just the right stage of development at the time when a large number of the midges were flying. Repeated attempts to rear the adult have been unsuccessful, though it is probably referable to the genus *Cecidomyia*.

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A NEW PREDACEOUS ENEMY OF THE COTTON BOLL WEEVIL

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So far as known to the writers there is no published record of any Carabid which attacks the boll weevil, *Anthonomus grandis* Boh.

While conducting some experiments with boll weevils in cages, during May of the present year, it was noticed that the adult weevils in one cage disappeared with remarkable rapidity. It may be remarked, by way of parenthesis, that in cages of the character used, weevils dying in the cages are usually found with ease on the ground around the growing plants. Especially is this true when daily examinations of the cages are made. In the cage referred to but few dead weevils could be found and the mortality among the weevils confined therein was several hundred per cent higher than the mortality in other cages under similar conditions. Upon close examination of this cage upon May 11th a small hole was noticed in the earth in one corner of the cage and at a depth of five inches in this hole was found a live Carabid together with elytra and other fragments remaining from the destruction of at least nine boll weevils.

This beetle we have identified as *Evarthrus sodalis* Lec., and from the number of weevil remains found with it, it seems not improbable that boll weevils constitute an important part of its food in the weevil-infested section.

A few days later another species of *Evarthrus*, as yet undetermined, was captured and placed in a glass jar with several live boll weevils. In the course of a few hours this Carabid caught and ate two of them.

It therefore seems that the several species of this genus may be regarded as probable enemies of the boll weevil and the part played by them in the natural control of the latter insect may prove to be of some little importance.

Baton Rouge, La., June 27, 1908.

THE INFLUENCE OF MINIMUM TEMPERATURES IN LIMITING THE NORTHERN DISTRIBUTION OF INSECTS[1]

By E. DWIGHT SANDERSON, *Professor of Zoölogy and Entomology, New Hampshire College; Director and Entomologist, New Hampshire Agricultural Experiment Station.*

For the past three winters the mortality of the larvæ of the brown-tail moth (*Euproctis chrysorrhoea*) in their winter nests has been determined by my students at different dates. January 24, 1907, the temperature dropped to —24°F. at Durham, N. H., the lowest tem-

TABLE I.[2]

Locality.	Date counted.	Minimum degrees F.	Per cent. dead.	Number nests.	Average number larvæ per nest.	Remarks.[3]
Durham, N. H..	Jan.-Mar. 1905........	—17	23	5	271	13 to 39% dead.
Durham, N. H..	Jan.-April 1906	—11	5	53	248	0 to 90% dead.
Durham, N. H..	Dec. 12-Jan. 23, 1907...	— 6	6.7	51	374	
Durham, N. H..	After Jan. 24, 1907....	—24	100	75	401	Nests from apple, etc.
Durham, N. H..	After Jan. 24, 1907....	—24	57	5	922	Nests from tall oaks.
Lewiston, Me...	Mar. 15, 1907..........	—24	72	15	239	
Bath, Me........	Mar. 23, 1907..........	—20	87	15	262	Temperature calculated
Rockland, Me..	Mar. 15, 1907..........	—20	51	15	325	from isotherms of Map I.
Bar Harbor, Me.	Mar. 15, 1907..........	—19	43	14	282	
Portland, Me...	Mar. 15, 1907..........	—16	98	15	464	
Franklin, N. H..	Feb. 20, 1907.........	—18	54	15	336	
Newton, N. H..	Feb. 20, 1907..........	—15	27	10	468	
Nashua, N. H..	Feb. 20, 1907..........	—13	8	15	608	Large nests on elm, oak.
Concord, N. H.	Feb. 20, 1907..........	—12	21	15	342	

[1]A paper read before the section of Economic Zoölogy, of the seventh International Zoölogical Congress, Boston, 1907.

[2]Since the above was written and Map 1 prepared I have received the following data through the kindness of Prof. E. F. Hitchings, State Entomologist of Maine, under whose direction the counts of mortality in the nests were made. (See page 246.)

[3]Nests were also received from Ossipee, N. H., where the temperature must have gone below —20° F. (see Map 1), in which all the larvæ were dead, and no live larvæ were found in nests at Ossipee according to a resident there.

perature recorded there,[1] and absolute minimum temperatures were also recorded at Orono, and other points in Maine. Nests were immediately collected from various localities in New Hampshire and Maine. The mortality record is given in the preceding table.[2]

Locality.	Lowest temperature, degrees F.	Per cent. dead.	Number nests.	Average number larvæ in nest.	Largest number larvæ in nest.
Portland,[3] Me.	—22 (—16)	68	10	389	638
Riggsville, Me	—20	11	10	315	394
Rockland, Me	—28 (*—20)	38	10	399	773
Prospect Harbor	—20	94	10	278	425
Oxford, Me	—20 (*—25)	98	10	282	507
Mechanic Falls	—20 (*—25)	71	10	269	429
Augusta, Me	—42 (—41)	100	10	264	383

These counts show that where average size nests of 300 to 400 larvæ were subjected to —24°F. or lower, that from 72% to 100% were killed, but that in large nests on oak from the same locality only 57% were killed. That the total mortality of the larvæ in the nests from Durham, N. H., after —24°F. on January 24, 1907, was due to the low temperature is demonstrated by there having been but 6.7% dead in 51 nests up to that date, when the mortality at once dropped to 100%. The detailed records of the individual nests show this absolutely.

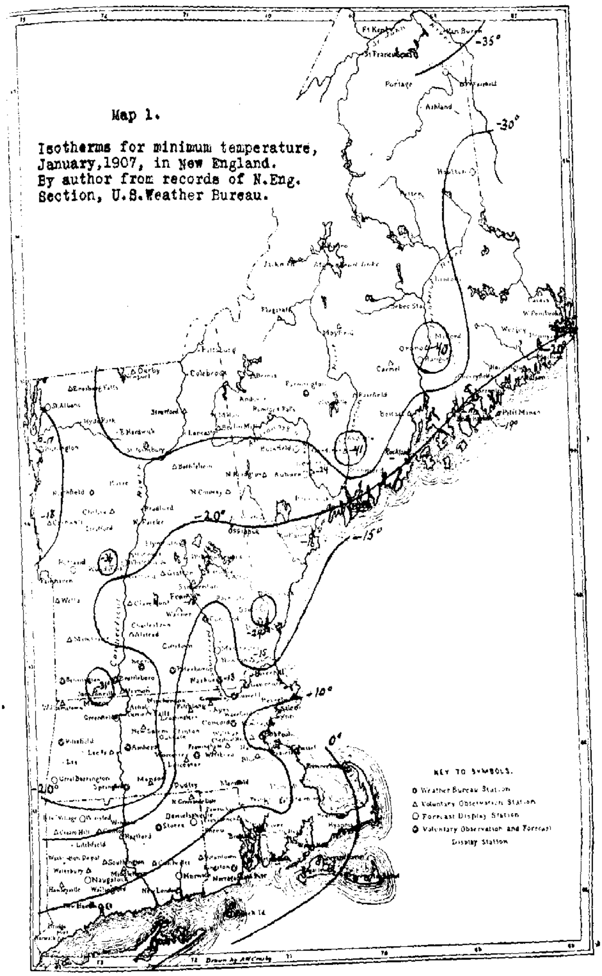
1 —24° F. was the official record of the station thermometer, but several thermometers in the town, whose accuracy need not be doubted, recorded —30° to —35° F.

2 The counts of the nests were made under the immediate supervision of my assistant, Dr. T. J. Headlee, who gave the matter most careful attention and who has prepared the preceding summary, Table I.

3 It is noticeable that the minimum for Portland is 6° below that of the Weather Bureau, as given in Table I, and Augusta is 1° below. There is reason to doubt the accuracy of some of these temperature records made by local and untested thermometers, for Oxford and Mechanic Falls are half-way between Lewiston and North Bridgton, in the same latitude, where weather bureau voluntary observers recorded —24°. Again, it seems remarkable that Rockland should drop to —28° when none of the five other coast points from Portland to Eastport registered below—20°. It would seem probable that Rockland was also about —20° F. I have therefore placed the readings made by weather bureau observers after those of Prof. Hitchings in ( ) and those based on the above remarks in the same way with an *.

The question at once arose whether the northern spread of this est might not be limited by such minimum temperatures, for over

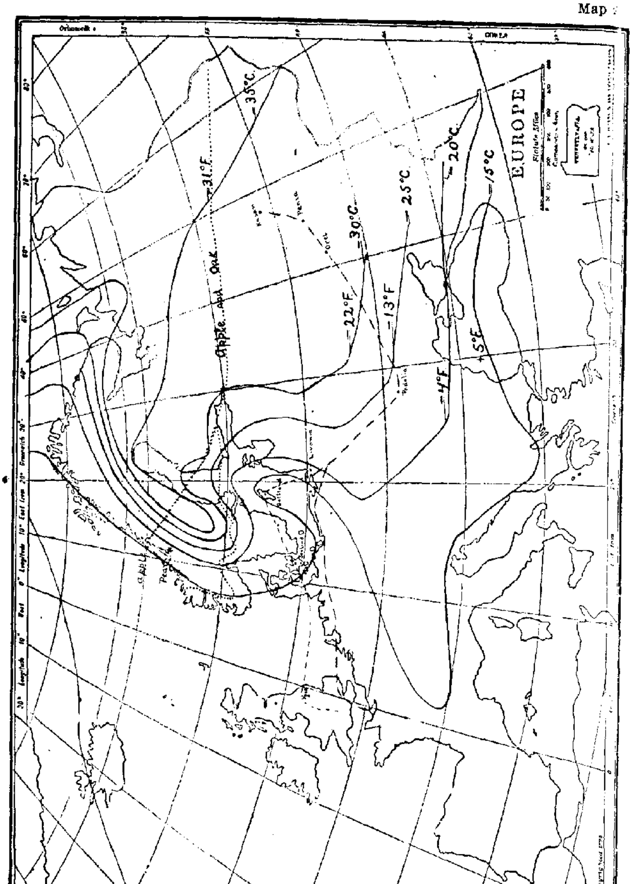
Map 1



most of the area to which the moth spread in Maine during 1906 the temperature dropped to —25° to —30°F.

Grevillius[1] has shown that if nests of the brown-tail moth be plac d in a freezing mixture giving a temperature of —30°C. (—22°F.) or

Map :



Map.2. Annual minimum isotherms of Europe. (Copied from Plate 2, Bartholomew's Physical Atlas, Vol.III, by J.W.Van Bibber) Northern boundaries of the Brown Tail Moth, Oak, Apple, and Pear as given by Grevillius (l.c. text). Compiled by author.

a short time, that most of the larvæ are killed, but that on with a minimum of —35°C. (—31°F.) were all killed in larger sts of

[1]Grevillius, A. Y., Botanischen Centrallblatt, Band 18, Zw. Abt., Hefte 2 (1905), p. 305-313.

9 to 359 larvæ. The minimum length of time at —35° C. necessary to kill them does not seem to have been determined. It should also be noted that most of the experiments were made with nests containing but few larvæ compared with those of this country, rarely containing over 100, while here the average is over 300 larvæ, and as has been shown the larger nests better withstand the cold. Grevillius notes that the larvæ in the outer parts of the nests are killed first and that those in the center survive. The size of the nest, therefore, greatly complicates the determination of the minimum temperature for this species.

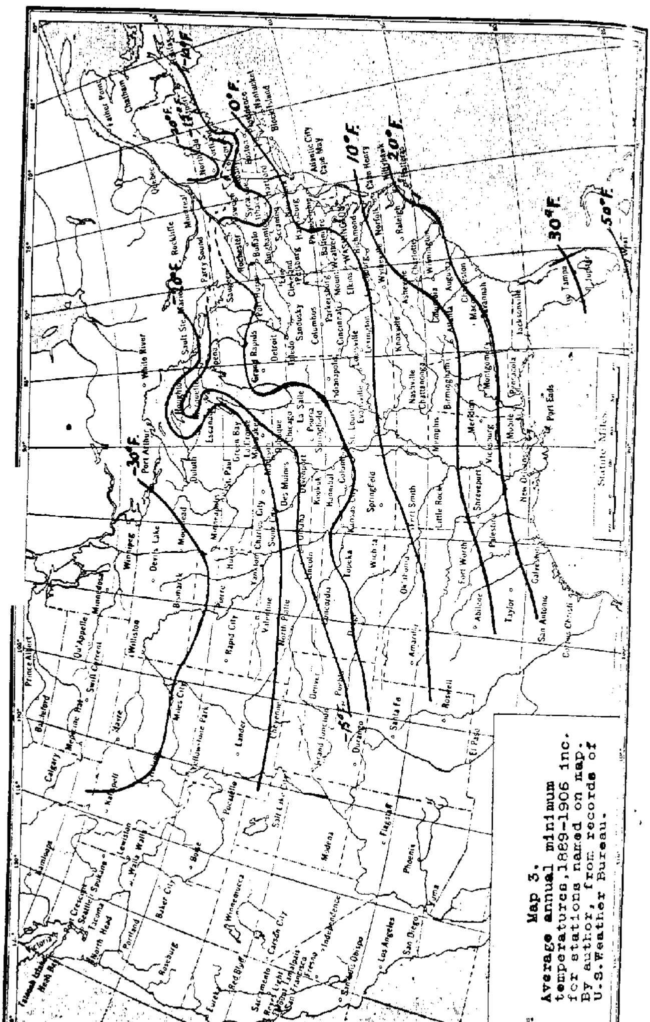
Comparing the northern limit of the brown-tail moth in Europe with the annual minimum temperature occurring there (see map 2), Grevillius remarks (l. c. pg. 314) that Kasan at the northern limit of the brown-tail moth in Russia has a mean annual minimum of —32° or —33°C., and that it is noteworthy that this temperature corresponds with the minimum temperature at which larvæ could exist in his experiments, but that there is a possibility that the larvæ may have adapted themselves to a lower temperature to which they may be exposed for a longer time than in his experiments. The relations of the isotherms of the mean annual minimum temperatures with the northern limits of the brown-tail moth, oak and apple in Europe are certainly suggestive. In northwestern Europe it seems well established that the pest is kept in check by the greater humidity encouraging the growth of fungous disease. The southward curve of the boundary of the brown-tail moth to Podolia follows that of the mean annual minimum isotherms, but its extension northeastward to Kasan cannot be accounted for thus.

From the elaborate researches of Bachmetjew[1] concerning the "critical point,"[2] it would seem that the maintenance of the temperature of the "critical point" for from a few minutes to not over half an hour would result fatally to the insect, and that the time required to produce death at any temperature above the critical point will vary conversely with the difference between it (the body temperature reached) and the critical point. Unfortunately the "critical point" of the body temperature of the brown-tail larvæ in their nests is

[1]Bachmetjew, P., Experimentalle entomologische Studien vom Physikalisch-Chemischen Standpunkt. (Leipzig, 1901) p. 80-90, 132-135.

[2]It is unfortunate that Bachmetjew has used the term "critical point" to define the temperature at which the protoplasm commences to freeze, in an entirely different sense from that previously employed by phenologists who designate the temperature above which positive or effective temperatures must be summed as the "critical temperature," as mentioned on pg. 255 of this paper.

Map



Map 3.
Average annual minimum temperatures, 1889-1906 inc. for stations named on map. By author, from records of U.S. Weather Bureau.

not known, but Grevillius' experiments certainly show that it is produced by an outer air temperature of —35°C. (–31°F.) and our records from Durham would show that with nests of similar size an air temperature of —24°F. (—31°C.) is fatal.

It would seem evident, therefore, that the larvæ of the brown-tail moth cannot exist in average size nests where the annual minimum averages —32° to —35°C. or —25° to —31°F.

The effect of minimum temperature on insect life has been frequently recorded, but little study has been given its significance, and only few writers have hazarded the suggestion that the northern distribution of insects might be governed by minimum temperatures.

Dr. L. O. Howard is the first writer, known to me, to definitely formulate this principle in America, though he mentions it as exceptional, and cites only one example. Concerning the American Locust (*Schistocerea americana*)[1] he says, "This species is one of the forms which would seem to indicate that in a few cases, at least, the winter temperature must have some effect in determining distribution. It is exceptional from the fact that it hibernates in the adult condition and we can hardly avoid the conclusion that it is limited in its northern range by circumstances which influence successful hibernation. Nothing is better known than that exceptional freezes may kill off thousands of insects; there must therefore be species whose successful hibernation is limited to certain degrees of cold."

Dr. F. H. Chittenden[2] emphasizes this and states that

". . . . in certain forms of insects the winter temperature must have some effect in determining distribution. While admitting that the past winter was exceptional as regards temperature, the writer feels confident in carrying conclusions still farther in stating that in his opinion, based upon the study of the effect of that winter on injurious northern and southern forms of insects occurring in that portion of the Carolinian or humid life areas of the Austroriparian and Alleghanian zones (a climate like that of the District of Columbia), mean winter temperature has more effect upon determining the rarity or abundance of these species than has the mean summer temperature."

To test this hypothesis, the writer has drawn the average annual-minimum isotherms for the regular stations of the U. S. Weather Bureau (see map 3) together with the maximum annual minimum[3] isotherms (see map 4).

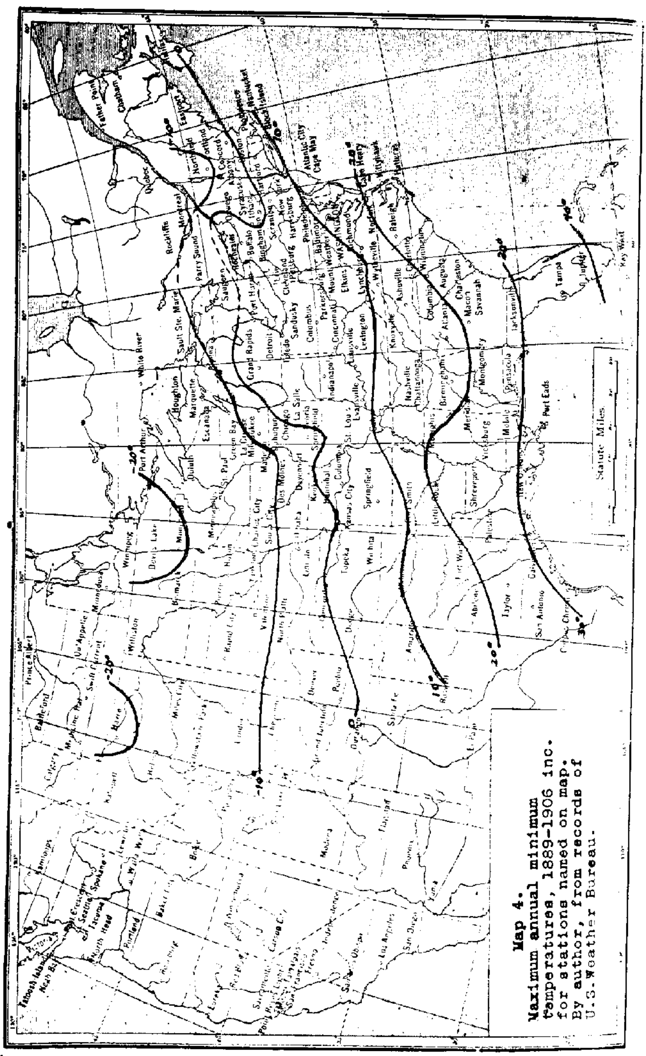
Comparing these with the isotherms of the absolute minima (see map 5), it is seen that the absolute minimum is usually about 10° lower, and the maximum annual-minimum 10° higher than average

[1] "Notes on the Geographical Distribution within the U. S. of Certain Insects Injuring Cultivated Crops," Proceedings Entom. Society, Washington, Vol. 3, p. 225.

[2] "Insects and the Weather: Observations During the Season of 1899," Bulletin 22, n. s., Division of Entomology, U. S. Dept. Agr., p. 62.

[3] I. e., the highest annual-minimum recorded.

Map 4



Map 4. Maximum annual minimum temperatures, 1889-1906 inc. for stations named on map. By author, from records of U.S. Weather Bureau.

annual-minimum, and that the absolute-, average- and maximum-annual-minimum isotherms follow approximately the same paths with the exception of the absolute minimum —20°F. Had the average

annual-minimum and maximum annual-minimum isotherms been drawn from records from all the voluntary observers, the dip in southern New York would have extended farther south and many isolated spots in the Alleghanies would stand out with lower temperatures than here indicated.

Upon comparing these isotherms with the boundaries of the life zones (see map 6), charted by Dr. C. Hart Merriam, many similarities become apparent, but also a number of important differences, and upon comparing the distribution of several well known injurious insects with the average annual-minimum isotherms, they were found to define the northern limits in some instances rather better than the life zones of Doctor Merriam.

The basis for the establishment of these zones has been stated by Doctor Merriam as follows:[1]

"Investigations conducted by the Biological Survey have shown that the *northward distribution of terrestrial animals and plants is governed by the sum of the positive* (or 'effective temperatures,' *i. e.*, over 43° F.—E. D. S.) *temperatures for the entire season of growth and reproduction, and that the southward distribution is governed by the mean temperature of a brief period during the hottest part of the year.*"

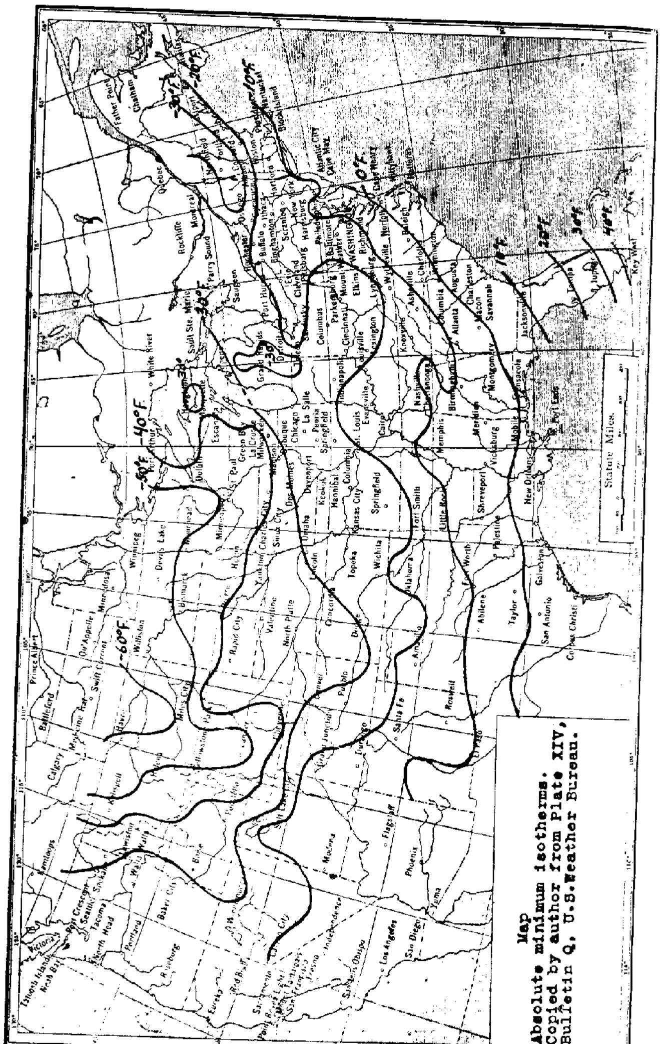
Isotherms plotted by Doctor Merriam on this basis were found "to conform in the most gratifying manner with the northern boundaries of the several life zones." In Bulletin 10 (l. c.) the "governing temperatures" of the zones are given and the maps previously published were slightly modified in agreement with this hypothesis, which map does not seem to have been revised in any subsequent publication.

The distribution of many common insects, some of which will be noted below, shows that there are numerous exceptions to the first part of this law, and leads us to question its validity as regards northward distribution. Is the *sum of the positive temperatures for the season of growth and reproduction* the only or most important factor governing distribution northward? At least three fundamental objections to this law being of first importance will be illustrated by the examples below.

First. Many insects which have two or three generations at 35° to 40° N. Lat. might readily reproduce in southern New Hampshire (about 43° N. Lat.) were their existence merely dependent upon a sufficient summation of temperature over 43° F. (6° C.) which do not

[1]Bulletin 10, Division of Biological Survey, U. S. Dept. Agr. (1898), p. 54.

Map 5



Map
Absolute minimum isotherms.
Copied by author from Plate XIV,
Bulletin Q, U.S. Weather Bureau.

occur north of Long Island, N. Y., southern Connecticut and Rhode Island in appreciable numbers. Other species which might hav one generation and exist in abundance if merely so limited occu but

sparingly in southern New Hampshire, if at all. That the "sum of effective temperatures" is an important factor is not disputed, but evidence accumulates that the "critical point" (in the sense of phenology) from which the "thermal constant" should be computed varies with groups and species of animals and plants. For example, melons and egg-plants are grown in eastern Massachusetts, but cannot be matured successfully at Durham, N. H. They are planted in Massachusetts about May 20 to 25 and in New Hampshire about June 1, and mature in Massachusetts about September 1. The effective temperature over 43°F. for Boston for the three months is 2343°F. and for Durham, N. H., 2061°F. The effective temperature in May and September is of no value in this connection. That these plants cannot be grown in New Hampshire is due to the fact that there is not sufficient "effective temperature" over 60°F., which is the temperature above which these plants must be grown, or their "critical point." Boston has 801°F. over 60° in summer, while Durham, N. H., has only 525°, or lacks 35% of the requisite effective temperature. Other examples will be given below.

Second. But even if the "effective temperatures" be accumulated above the true "critical points" instead of over 43°F., still there are numerous cases in which there is a sufficient positive temperature for the development of species in southern New Hampshire which are not known to breed there or in eastern Massachusetts commonly. Some other law must therefore determine the limitation of these species to a more southern clime.

Third. It is well known that the main question in the introduction of horticultural varieties northward is one of "hardiness." Many varieties will fruit and mature at latitudes where they cannot grow on account of lack of hardiness. Probably as large a number are disqualified for northern growth on this account as by the shortness of the season.

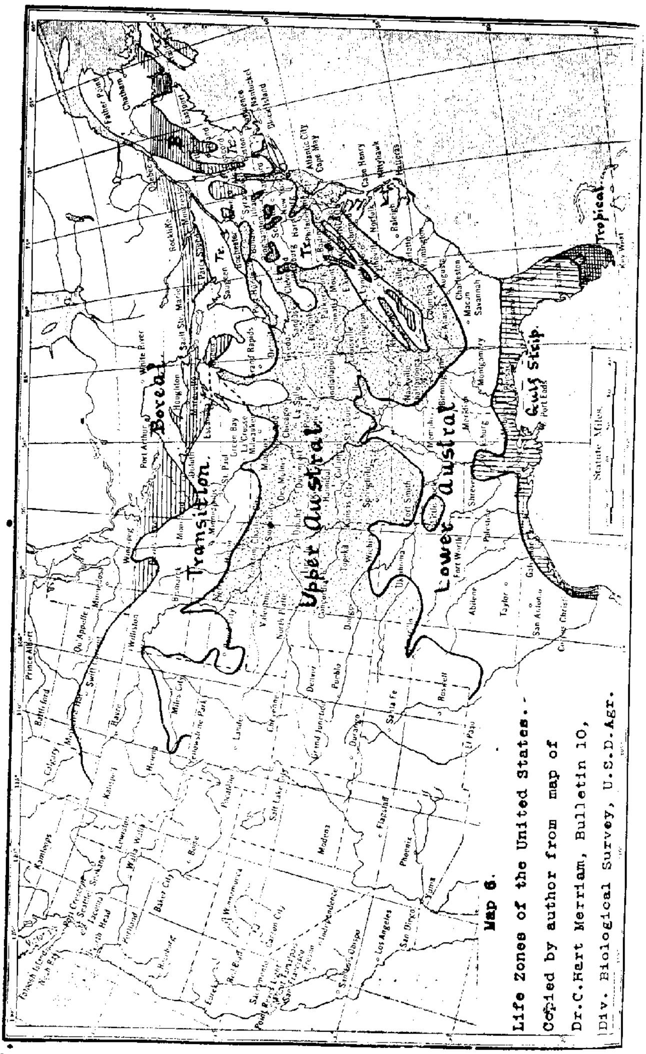
If the southern spread of some species is controlled by the heat of summer, which is undoubtedly the case, why should not the direct opposite be true, and why may not the northward spread be controlled by the cold of winter?

The following species have been studied with reference to these objections and as to whether the influence of minimum temperatures offers any explanation of their northern limits.

The Harlequin Cabbage Bug (*Murgantia histrionica*) has migrated from Mexico around the Atlantic coast to Long Island, N. Y., and up the Mississippi Valley to southern Ohio, where it occurred in five counties bordering the Ohio River in 1895.[1] In 1899 the temper-

[1]Bulletin 68, Ohio Agricultural Experiment Station, p. 36 (1896).

Map 6



Map 6. Life Zones of the United States.- Copied by author from map of Dr.C.Hart Merriam, Bulletin 10, Div. Biological Survey, U.S.D.Agr.

atures at Cincinnati dropped to —17°F. and in these counties to about —20°F. As a result, Prof. F. M. Webster stated that the insect had "certainly sustained a severe repulse by the low temperature of last winter. While observed breeding in Clermont County, south-

ern Ohio, last May, its almost entire absence has been reported in localities where last year it was disastrously abundant."[1] Later Professor Webster stated[2] that it "had spread at one time as far north as Chicago, Ill., and had almost reached the shore of Lake Erie in Ohio. A very severe winter, however, had killed it off in southern Illinois and Ohio, and it has not recovered this lost ground, and might not again in years." It probably still occurs in extreme southern Ohio according to Prof. H. A. Gossard and was noted by Professor Webster in 1901. Doctor Chittenden[3] noted its scarcity in Washington, D. C., in 1899, following a minimum of —15°F., and the writer made the same observation in Delaware. This was the lowest temperature which had been experienced at Washington for over twenty years. As it was accompanied by heavy snow, the harlequin bug was largely protected from the severest cold, otherwise it would doubtless have been exterminated.

The harlequin bug emerges from hibernation at Newark, Del., about May 1, when the temperature is about 55°F. In midsummer, at 74°F., the life cycle there occupies about one month. The life cycle thus consumes 1236°F. over 43°F. At Durham, N. H., there is 2925°F. over 43° from the middle of May to the middle of September, during which time the mean is over 55°F., and according to Merriam's law the species might exist there with two generations. But even if we take 55° as the critical point, there is required but 726° for a life cycle in Delaware and there is available 1119° at Durham, N. H., enough for one brood. But the harlequin bug does not occur north of Long Island, N. Y., and is not spreading there. The northern limit of this species follows the average annual-minimum isotherm of 0°F. (map 2) much more closely than the Upper Austral Zone. It may yet migrate to northern Ohio and Ontario, but further progress seems doubtful.

The Cotton Boll Worm or Corn Ear Worm (*Heliothis obsoleta* Fab.) is injurious throughout the upper and lower Austral zones, but only exceptionally in the transition. It has been injurious at London, Ont., near Boston, Mass., in 1894, and rarely in Michigan. It does not winter in Minnesota and no records of injury occur in Dakota, Montana or Wyoming.[4] Professor Quaintance remarks, "The severe character of the winters of the more northern states coupled with the relatively low sum of effective temperatures, no doubt has

[1] Bulletin 20, Bureau of Entomology, U. S. Dept. Agr., p. 72 (1899).
[2] Bulletin 60, Bureau of Entomology, U. S. Dept. Agr., p. 130 (1906).
[3] Bulletin 22, n. s., Division of Entomology, U. S. Dept. Agr., p. 55.
[4] Bulletin 50, Bureau of Entomology, U. S. Dept. Agr., p. 26-27.

an important bearing on the comparative immunity of this territory from serious injury." Doctor Chittenden reported the species rare on corn at Washington, D. C., in 1899 following —15°F. in February, where it is usually very abundant.

Eggs of *H. obsoleta* were laid at Newark, Del., about June 12, 1900, and moths from them emerged July 15, at a mean temperature of about 73°F., thus requiring approximately 900° above 43°F. Quaintance (l. c.) found the average effective temperature in Texas to be 1417°F. He also shows (l. c. p. 86) that the sum of the effective temperatures for pupal development are more nearly equal for different temperatures when computed above 58° or 60° than above 43°F. He also shows that at Boston, Mass., there could be two generations with a total effective temperature of 2967°F. over 43°, commencing when the monthly mean has reached 62°F., or May 1. Further, if 58°F. were taken as the critical point, there would have been required in 1900 only 450° at Newark, Del., while there were 801° at Boston and 525° at Durham, N. H. Yet the species breeds only rarely in eastern Massachusetts, according to Dr. H. T. Fernald, and is practically unknown at Durham. The summer temperature evidently does not control the northern limit in this case, though the distribution of the species is practically that of the Austral zones. May not the minimum temperature be the controlling factor?

Prof. F. M. Webster records[1] that the West Indian Peach Scale (*Aulacaspis pentagona* Targ.) withstood —9° during 1897–'98 sufficiently to increase in numbers the next season at Wooster, Ohio, but that in 1899 the temperature fell to —21° one night and to —12° to —18°F. in several successive nights, with the result that all of the scales succumbed.

Mr. C. L. Marlatt[2] calls attention to the influence of the minimum of 1899 (—15°F.) at Washington, D. C., on scale insects, 95 to 100% of such species as *Diaspis pentagona, D. rosae, Aspidiotus perniciosus*, and others being killed. He points out that such mortality is more likely to occur at Washington where the hibernation of these scales is short and where low temperatures are rarer than further north.[3]

At Nashua and Manchester, N. H., during the past winter something over 60 per cent of the scales were killed by —13°F., but are breeding abundantly now.

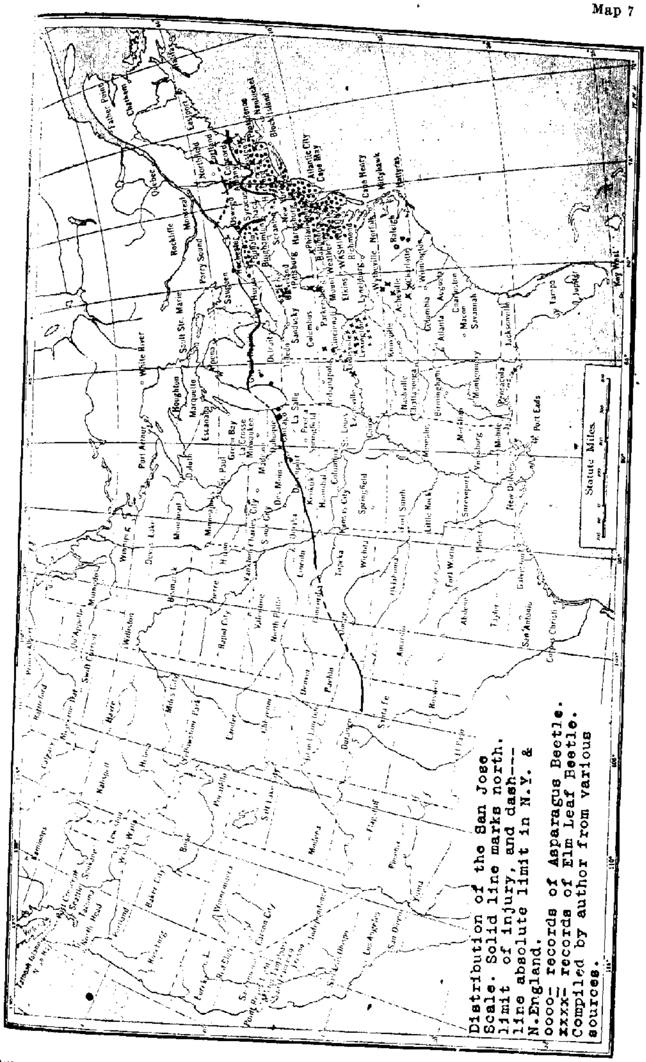
The northern limit of the San Jose Scale is shown on map 7. The

[1]Canadian Entomologist, XXXI, p. 130 (1899).

[2]Bulletin 20, n. s., Division Entomology, U. S. Dept. Agr., p. 76.

[3]See also Voyle, Bulletin 4, old ser., Div. Entomology, U. S. Dept. Agr., p. 70–75, "Low Temperatures vs. Scale Insects."

Map 7



Distribution of the San Jose Scale. Solid line marks north. limit of injury, and dash--- line absolute limit in N.Y. & N.England. oooo- records of Asparagus Beetle. xxxx- records of Elm Leaf Beetle. Compiled by author from various sources.

hope, as expressed by Dr. L. O. Howard,[1] that this species would be limited to the upper Austral has not been realized, though the excep-

[1]Proc. Wash. Ent. Soc. III, p. 222 (1895).

tions occur only in Michigan, Massachusetts, New Hampshire and southwestern New York. The average-annual-minimum isotherm of —15°F. corresponds much more closely with the northern limit of this species than the upper Austral as given, with the exception of northern Michigan and Ontario, but approaches the limit of the scale much better in Iowa and Nebraska, which are wholly within the upper Austral, but where the scale is practically unknown. The annual-minimum temperature of its native home in China is about 5 F., according to Bartholomew's Physical Atlas, Vol. III, Meteorology, Plate II.

Based upon the data given by Marlatt[1] concerning the life history of the scale, there can be two generations in southern New Hampshire, with an effective temperature of 1570°F. over 53°F., a single brood requiring 600°F. over 53°F. at Washington, D. C., and reproduction commencing at both points when the mean is about 63° F.,—at Washington May 15, at Nashua, N. H., about June 15. Two generations occur in southern New Hampshire according to our observations.

The Asparagus Beetle (*Crioceris asparagi*) was first imported near New York City. It occurs in southern New Hampshire, but is very rarely injurious, often dying out for several years. Chittenden records that it was introduced and completely died out at Rock Island, Ill., many years ago. Its northern limit agrees quite closely with the average-annual-minimum isotherm of about —10°F. (see map 3). It occurs in southwestern New York and northeastern Ohio in the transition. Doctor Chittenden[2] quotes C. W. Prescott of Concord, Mass., as stating that "immense numbers are killed in winter during severely cold spells following open weather" and states that the beetles are quite susceptible to low temperatures. Indeed Doctor Chittenden[3] definitely attributes the limitation of the northward spread of this insect to "cold snaps." At Washington, D. C., the beetles emerge from hibernation in April with a mean of about 55°F. The life cycle from egg to adult occupies three weeks, or an effective temperature of 420°F. over 55°, or 300° over 60°F. at Washington, yet it is not common at Durham, N. H., though 1119° over 55° and 525°F. over 60°F. are available.

The distribution and data concerning the life history of the Elm Leaf Beetle (*Galerucella luteola* Müll.) practically duplicate that given for the asparagus beetle and do not need to be enumerated here.

[1]Bulletin 62, Bureau of Entomology.

[2]Yearbook U. S. Dept. of Agr. 1896, p. 347.

[3]Bulletin 22, p. 63, note.

In its northern spread the Cotton Boll Weevil (*Anthonomus* *andis* Boh.) had reached the northern boundary of Texas at the d of 1904. In February, 1905, the temperature dropped to 1°F. Dallas and 14°F. at College Station, Texas. As a result, I am informed by Prof. A. F. Conradi that it seemed to have been killed out tirely north of Dallas and the spread of the previous season was offset, while as far south as College Station so few hibernated successfully that but comparatively little damage was done the following season. The advance of the weevil was also given a decided set-back in Louisiana the same winter, though only in the northern part can this be attributed to low temperature. Again in June, 1906, the agents of the Bureau of Entomology were unable to find weevils which had hibernated successfully in Dallas, Ellis and Navarro counties, Texas, which had been infested for three or four years, following a minimum of 12°F.[1]

It is also interesting to note that from the first, the boll weevil and other southwestern insects have spread much faster eastward than northward.[2]

About 1903 the Morellos Orange Fruit Worm (*Anastrepha ludens* Loew) was introduced from Mexico and became established near Brownsville, Texas. Prof. A. F. Conradi, state entomologist of Texas, advises the writer that it had become quite abundant in this region, but since the freeze of February, 1905, when a minimum of 22°F. occurred, he has been unable to find any evidence of the pest.

It is probable that the absolute minimum temperature is not the controlling factor in limiting the northward spread of insects, for many individuals would always survive in sheltered situations, and these absolute minima occur at very long intervals. But it would seem evident that where the average-annual-minimum temperature is below that at which a species can exist, that it will never become abundant. Inasmuch as the extreme cold of winter is usually in spells of short duration, the average-annual-minimum temperature of any locality is probably a better index of the effect of winter temperature there than the average mean temperature, average daily minimum, etc. Were thermograph records available for the different stations, a summation of the temperatures below a certain point might possibly be more accurate, for it must be remembered that, as Bachmetjew has shown, an insect may be killed by more protracted cold at

[1] For further discussion see a forthcoming bulletin of the Bureau of Entomology, "Some Factors in the Natural Control of the Mexican Cotton Boll Weevil."

[2] Webster, *et al*, Bulletin 60, Bureau of Entomology, p. 130.

a temperature considerably above its "critical point," or absolute minimum.

Snowfall will exercise an important influence in limiting the effect of minimum temperatures. Thus the present season the Rose Chafer (*Macrodactylus subspinosus*), whose larva winters in the soil, has been exceptionally abundant, and the Striped Cucumber Beetle (*Diabrotica vitatta*), which hibernates in the earth, has been as injurious as usual, in spite of the low temperatures of last winter, both having been protected by the deep snow blanket. Species hibernating above ground will therefore be most susceptible to minimum temperatures. Humidity will also materially affect the influence of minimum temperatures.

From the above discussion it seems that the following conclusions may safely be drawn:—First, that the present Upper Austral Zone of Doctor Merriam does not extend far enough to the northeast and extends too far to the northwest. Second, that there is strong evidence against the effective temperature of the growing season being the only or controlling factor in determining the northern limits of life areas. Third, that minimum temperatures often limit northern distribution. Indeed, is it not probable that the laws governing the distribution of life are a complex resulting from many different causes which are of variable importance with each species? Though hypotheses concerning the general principles involved are of the greatest value in forming a basis for further investigation, yet the true life zones can only be ascertained by a patient accumulation of data concerning the actual distribution and spread of life as found, when a comparison with the known physiographical and meteorological conditions will make apparent the laws underlying the distribution of life.

TWO INTERESTING INQUILINES OCCURRING IN THE NESTS OF THE ARGENTINE ANT

WILMON NEWELL, *Baton Rouge, La.*

In the February issue of the JOURNAL quite lengthy mention was made of the habits of the Argentine ant, *Iridomyrmex humilis* Mayr, which has become a pest of serious nature in the southern parts of Louisiana and Mississippi.

Although the writer has had this species under constant observation for the past ten months, not a single parasitic or predaceous enemy of it has been discovered. The insects which dwell with this ant, in its colonies, are very scarce and none of the true insects are as yet posi-

ively known to be persistent guests or constant dwellers in the olonies of this species. Certain *Staphylinidæ* are found in decaying ogs and in rubbish heaps which are literally honeycombed with the alleries of the Argentine ant, yet these beetles, when confined in the rtificial formicaries with populous colonies of this ant, fail to survive. In fact, when placed in a formicary they are invariably attacked by the worker ants. Whether this is due to the unnatural conditions surrounding the ants is a question, as the ants live, thrive and increase in the artificial formicaries with apparently the same freedom and facility as in the purely natural outdoor colonies.

The first and only true guests as yet observed in the colonies of the Argentine ant were found by the writer in March of the present year. Upon examining a large colony located in a heap of decaying cotton seed and straw, thousands of brown mites were found and while the first impression was that they were breeding in the decaying vegetation, examination of the entire heap showed that the mites occurred only in the heart of the ant colony.

Specimens of these mites were sent to Dr. L. O. Howard, who submitted them to Mr. Nathan Banks of the Bureau of Entomology. Mr. Banks found that there were two distinct species, both new, and he kindly prepared descriptions of them as follows:

Uropoda agitans n. sp.

"Body oval, in the female slightly more pointed behind than in the male; about one and one half times as long as broad, broadest behind coxæ III and IV; the anterior tip of the body frequently depressed a little so as to appear slightly emarginate in front. Dorsum smooth, two little bristles in front under anterior margin; venter with a few short, stiff bristles, a pair slightly in front of the anus and a pair more widely separate behind. Peritreme very large at stigma, a slight projection beyond, anterior part at first curved, then extending obliquely forward and outward, then suddenly turned upon itself it runs back and diverges toward coxa II. Female genital aperture large, occupying all the area between coxæ and reaching to the camerostome, and behind to middle of coxa IV; the male genital aperture is only a little longer than broad, and about its length from the camerostome. Legs short, I with many hairs near tip, one as long as tarsus, other legs with short spines, most numerous on the tarsi. Hind tarsi about as long as space between hind coxæ. Length 9 mm.

"Baton Rouge, La.; associated with the Argentine ant."

Uropoda provocans n. sp.

"Body elongate oval; tip more acute, anterior end slightly produced in the middle. Dorsum with many prominent bristles; the two bristles under anterior margin are very long, two thirds as long as tarsus I; venter with a number of bristles. Peritreme large, with a very small inner prolongation, anteriorly it runs nearly straight at first, then curves outward and turns

on itself and runs toward coxa II. Female genital aperture not quite reaching the camerostome, and behind hardly extending to coxa IV. Male genital aperture one and one-fourth times longer than broad, and still farther from the camerostome. Legs of moderate length; the tarsi quite slender, I with many bristles near tip, one of them as long as the tarsus, other tarsi with short spines, the hind tarsus fully as long as space between hind coxæ. Length 1. mm.

"Baton Rouge, La.; associated with the Argentine ant."

For the purpose of determining the habits of these mites and the part played by them in the economy of the ant colonies, several hundred were placed in a colony of the Argentine ants, confined in a modified Janet cage, cast of plaster of Paris and containing five chambers, four of which connect with each other by means of small tunnels, the fifth chamber being for the reception of water to maintain humidity in the nest. In a cage of this character one chamber, usually the one furthest from the entrance, is invariably "set aside" by the ants as a cemetery, in which all dead individuals, refuse matter from the nest, etc., is deposited from time to time. It has been our custom to leave the chamber nearest the entrance covered only with glass, to form a sort of "vestibule" to the nest proper.

Fine trash, containing eggs, larvæ and pupæ of the Argentine ant as well as hundreds of the two species of mite were placed in the vestibule of one of these cages on March 11th. The workers immediately selected all ant larvæ, eggs, and pupæ from the trash and carried them into the nest proper, paying no attention to the Uropodas and neither attempted to destroy them nor carry them into the nest. The vestibule, or outer chamber, was by far the dryest compartment and during the two following days the Uropodas which failed to find their way through the small tunnel into the nest proper perished, either of starvation or lack of moisture. On the third day following their introduction, some of the living mites were in the nest with the workers and young, but the great majority had found their way through the two living chambers and three tunnels to the back chamber or "cemetery," where they were feeding upon the refuse matter placed there by the ants. Since that date, a period of about 100 days, the mites have continued to thrive in this colony. The mites never attack the immature stages of the ant nor do they seem to cause any annoyance or inconvenience to the latter. The ants, for their part, seem to be entirely indifferent as to the welfare of the mites. They never attempt to remove them or care for them, but appear to regard them with a spirit of kindly toleration. Observations made upon these mites in other colonies but served to verify these conclusions. In the case of one Janet cage the solvent action of the water, which

was added from time to time to preserve the requisite amount of moisture within the cage, resulted in small cavities being formed outside the nest. From time to time a mite would find its way into one of these cavities and would remain there for a longer or shorter time. Such mites were constantly watched over by a detail of from two to six workers from the colony and while the workers never fed or in any other manner cared for the mites, so far as could be determined, they were nevertheless unremitting in their self-imposed guardianship both day and night.

That the mites were in no way dependent upon the ants for food or for care was determined by placing several hundred of the former in a plain glass bottle with a small supply of worker and larva "cadavers" and other refuse matter taken from the cemeterial chamber of a large artificial formicary. Water was added from time to time to keep the mass sufficiently moist and the bottle isolated by water to prevent any living ants from obtaining access to it. On this dead and decaying matter the mites lived and thrived for over sixty days, when other duties caused us to neglect the daily application of moisture and the death of the mites resulted.

We therefore feel safe in venturing the opinion that these two mites are scavengers, pure and simple, in the colonies of the Argentine ant and as such they are tolerated by the latter, although their presence is not necessary to the welfare of the community and no effort is made by the ants to secure or retain their services.

Careful search in the colonies of other species of *Formicina* has thus far failed to reveal the presence of either of these two species of *Uropoda*.

Baton Rouge, La., June 22, 1908.

THE FUNDAMENTAL PRINCIPLES OF SPRAYING

By H. T. Fernald, *Amherst, Mass.*

The use of arsenical poisons in the control of insect pests has now continued for nearly half a century. During that period, starting with but a few pounds a year, the demand has increased until many tons of these materials are now annually consumed and their use is one of the fundamental principles of economic entomology. Yet, a careful examination of our actual knowledge of arsenicals in their relation to insect and plant life gives surprising results, showing how little is really known and how much is merely empirical, and in-

dicates that a broad field for chemical, entomological and physiological research is waiting for explorers.

Everyone who sprays is aware how variable are the results he obtains at different times; how one treatment may be very successful while another, under apparently similar conditions, may prove much less satisfactory. Some writers advise spraying on warm, cloudy days; others on bright days to obtain the best results. The addition of one or two pounds of lime to each pound of Paris Green to prevent burning the foliage is generally urged; yet, even then, injury sometimes follows, and the only explanation generally offered seems to be that the materials were not sufficiently well mixed.

It is generally claimed that injury to foliage is due to the presence of free (uncombined) arsenic in the spray, but it is interesting to note that even this has not been conclusively proven. And when the nature of the action of the poison on the insect is questioned, the answer seems to have been drawn entirely from human toxicology rather than from a study of the poisoned insects themselves, while differences in the ease with which different pests are killed by poisons have been explained as due to varying powers of elimination of the poisons from their bodies,—only a guess, though one which may prove to be correct.

Even the chemical aspect of the insecticides has its uncertainties. Dictionaries of solubility state that copper arsenite is insoluble in water, whereas everyone who has used this substance as a spray knows that it is necessary to add lime to prevent burning the foliage. It would seem then, either that such statements as to solubility are very loose in their nature, or that the burning is due to some of the impurities always present in commercial articles. Which is the truth? What are the impurities and what parts may they play when used as sprays? These and many other questions must be settled by the chemist and entomologist working together.

Weather conditions have already been mentioned. How far do these affect or modify results when other factors remain fixed? Is it sunlight, temperature, humidity or all these and perhaps other conditions in addition which are involved? The meteorologist must also contribute his share toward the solution of spraying problems.

At the present time there are too few data of experiments made under conditions known with exactness; with materials of fixed and known composition; and with careful studies of the results, to enable us to draw safe conclusions on this subject. Many factors are involved and these must each be studied separately in their changes while the others remain fixed, thus involving long series of experi-

ments, before we shall have a knowledge of the fundamental principles which will enable us to attain the best results. Such an investigation has already been begun at the Massachusetts Experiment Station with the anticipation that five or ten year's work may give results which will help place spraying on a firm and scientific basis.

DESCRIPTION OF NEW DEVICES FOR REARING INSECTS

By A. F. Burgess, *Washington, D. C.*

One of the serious problems which it was necessary to solve in order to successfully rear the parasitic and predaceous insects which were being shipped from Europe to prey on the gypsy and brown-tail moths was to secure apparatus by means of which these insects, as well as their hosts, could be successfully reared in large numbers. All of the old style equipment in general use by entomologists for rearing work was tested, but in many cases it was found that radical improvements were necessary in order to accomplish the results desired. It was of primary importance to place the insects under as nearly as possible natural conditions and at the same time to keep them in confinement where they could be studied and observed and not allowed to escape from captivity. The purpose of this paper is to call the attention of working entomologists and others who may be interested in rearing insects to several devices which are now in use at the Gypsy Moth Parasite Laboratory, Melrose Highlands, Mass., and which have been found to meet some of the serious defects of the equipment that is in general use in insectaries and insect-breeding laboratories.

The most important of these is a tray for rearing insects which was devised by Mr. W. F. Fiske of the Bureau of Entomology, Washington, D. C., who is in charge of the Parasite Laboratory. It is illustrated in Pl. 3, Figs. 1 and 2. The standard size used at the laboratory is 14 in. square and 3 in. high. The bottom is covered with cheese-cloth which is attached by paste to the sides of the tray. With the exception of a 2-in. rim around the upper edge, the top is open; while directly beneath this rim a band of sticky Tanglefoot is placed in order to prevent the escape of the insects. This band is applied before the cheese-cloth bottom is attached and it is a simple matter to replace the bottom with a new piece of cheese-cloth when desired. The tray is built of one half inch white wood stock and the joints are securely nailed and glued in order to make it tight. A modification

of this tray has been used with excellent results for rearing larvæ in large numbers. This form is 5 feet long, 2 feet wide, and 4 inches high. *Approximately 300 trays of these two sizes have been in use* this season and the results have been entirely satisfactory. The advantages of this device over the ordinary Riley cage are very pronounced. Any one who has used the latter for rearing large quantities of larvæ has been confronted with the difficult problem of feeding the caterpillars without allowing them to escape. It is impossible in one of these cages to secure reliable data on feeding habits of the insects, which are being reared, and information concerning the habits of their parasitic enemies cannot be readily obtained because of the small area contained in the cage and also on account of the inability of an observer to watch the oviposition of parasites on their larval hosts. The Fiske tray overcomes practically all of these difficulties. The caterpillars are made to feed in such a way that they are exposed to the view of the observer, the Tanglefoot band preventing them from escaping from the tray. In case it is desired to make observations on the oviposition or habits of parasitic insects which attack the caterpillars, these trays can be placed in a tightly screened room or house in which the parasites may be liberated and where the observer can have ample opportunity to observe their operations.

For the purpose of rearing some insects, such as beetles which spend a part of their life in the ground, it is usually desirable to use glass jars partially filled with earth. We have in the past used cheesecloth covers, which were held in place by rubber bands or string. Both of these methods of fastening are objectionable, the former on account of the continual breaking of the bands and the latter because of the annoyance in untying the string to remove the cover. Some insects are able to cut through the cheesecloth and make their escape and this has often caused the loss of specimens from which valuable data was being secured. This year we have used a circular, wooden cover made of one inch planed pine. (See Pl. 4, Fig. 3.) A groove was turned one half inch from the outer edge of the cover and of sufficient width to admit the upper edge of the jar. A 2-inch hole was then cut or bored in the center, the under side of which was covered with wire mosquito netting. This furnishes a cover which can be easily removed and replaced and is tight enough to prevent the escape of insects which are being reared. The wire netting in the top furnishes sufficient air supply to prevent condensation of moisture on the inside of the jar.

Another cage which has been successfully used this season for rearing Calosoma larvæ is illustrated in Pl. 4, Fig. 4. It is 10 inches in

Plate 3

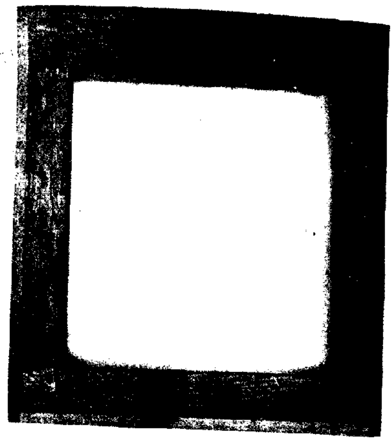


Fig. 1.

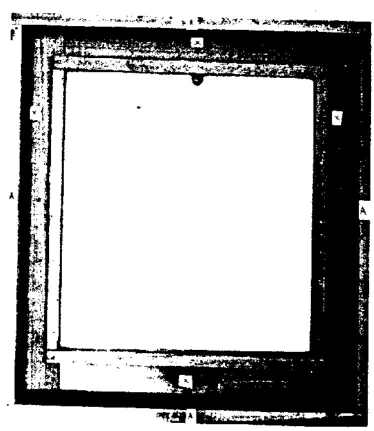
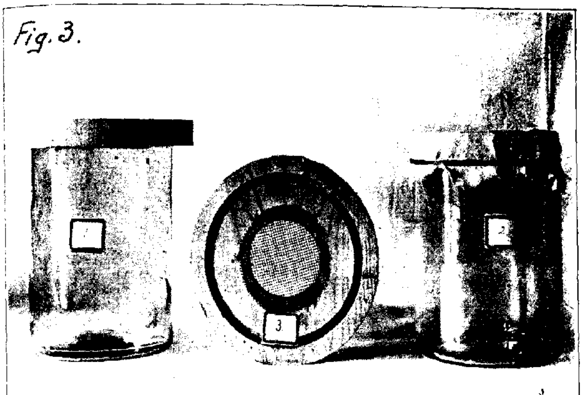
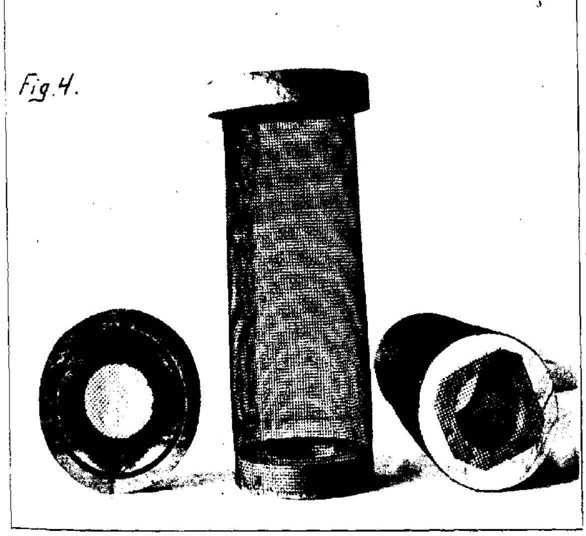


Fig. 2.

FISKE TRAY: Fig. 1.—Top view of Fiske breeding tray. Fig. 2.—Bottom view of same before cheesecloth bottom is put on. *A* indicates where the cloth will be placed on the bottom. It must be large enough to lap over and be pasted on the sides. *X* indicates where the band of Tanglefoot should be applied.

Plate 4





Beetle Cages: Fig. 3.—No. 1, jar with wooden top. No. 2, jar with cheesecloth top held in place with rubber band. No. 3, construction of under-side of wooden top. Fig. 4.—Illustrates construction of wire cage for rearing insects in the ground. The side figures show the top and bottom of the cage, while the middle figure shows the completed cage, which can be sunk in the ground to the distance desired.

...ght, 4 inches in diameter, the sides are made of wire mosquito netting drawn into the form of a cylinder and laced with copper wire. The top is similar to the one already described which is used on the glass jars; while the bottom is made in the same way but without the groove. The lower edge of the wire is tacked securely to the wooden surface. In making these cages netting, 20 inches wide, was used, the finished edge always being placed at the top. These cages were sunk about 8 inches into the ground and furnish conditions which are as near natural as we have been able to devise for rearing insects of this class.

A larger cage for hibernating Calosoma adults has been used in our breeding experiments. It is made of galvanized iron wire, 2 feet in width and with a three eighths inch mesh. A strip was cut and rolled into a cylinder, the diameter of which was 5 inches; the overlapping edges were laced with copper wire and the top and bottom, which were made of wire mosquito netting, were sewed on with wire. The cage was sunk 20 inches in the ground and furnished excellent conditions for hibernating these insects.

It is perfectly true that breeding devices must be used which are especially adapted to the habits and character of the insects to be studied, and it may be desirable to modify these cages in such a way as to suit the special needs of the investigator. For the lines of work which we are attempting, the results secured have been very satisfactory and it is hoped that these devices may be of assistance to others engaged in like work.

REPORT OF THE COMMITTEE APPOINTED TO ATTEND THE ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF NURSERYMEN

At the last annual meeting of this association, a committee was appointed, consisting of Doctor S. A. Forbes, Prof. T. B. Symons and Mr. A. F. Burgess, to attend the annual meeting of the American Association of Nurserymen at Milwaukee, Wisconsin, June 10, 11, 12, 1908, for the purpose of conferring with the members of that association relative to matters pertaining to nursery inspection and also in regard to the proposed national inspection and quarantine legislation. Doctor Forbes was unable to be present and the committee was represented by the other members.

At the session held on Wednesday morning, June 10, the following report was submitted by Mr. Orlando Harrison of Berlin, Maryland.

who was the Nurserymen's representative and joint committee on national inspection and legislation:

Mr. President and Members of the American Association of Nurserymen:

The subject of a national inspection law is one that should receive the attention of every nurseryman. It has been said that a poor law is better than none, and I think we all agree that it is better to have a law enforcing inspection for the benefit of all the fruit-growers, entomologists and the nurserymen.

The question now is "Do you want two laws?" One operated by the state and the other operated by the government from Washington, like the Pure Food and Seed laws, as they are now enforced.

Who is to be supreme, the state or the government, in enforcing them?

At a recent conference of the governors of the various states at Washington, D. C., it was made clear that the states, so far as their governors were concerned, are scrupulously opposed to relinquishing to the federal government any of the powers reserved to them under the constitution. Practically every governor present went on record in favor of the states exercising their power to the fullest degree, but in doing this, they also made it clear that they, likewise, favored the exercise by the federal government in the fullest sense of all the powers delegated to it by the states through the constitution. The concensus of opinion seems to be that the states must do their work, the nation its work.

When Federal Power Should Prevail

President Roosevelt has gone on record as recognizing the rights of the states and says in matters that relate only to the people within the state, the state is to be sovereign and it should have the power to act. If the matter is such that the state itself cannot act, then he pleads on behalf of all the states that the national government should act.

Each Must Exercise Its Power

William Jennings Bryan says he is jealous of any encroachment upon the rights of the state, believing that the states are indestructible as the Union is indissoluble, and it is just as imperative that the general government shall discharge the duties delegated to it as it is that the states should exercise the powers reserved to them. He further says, "Nothing that is necessary is impossible."

State Rights

Without state rights we would have no government. Eliminate state rights and you have nothing.

Advantage of a National Law

One thing that could be gained in a national law is to outline a standard law and ask all the states to amend their laws to conform to that as far as practicable. We must remember that the United States government has no power except that given it by the states.

Now it must be taken for granted that the American Nurserymen thought it necessary that something should be done or this committee would not have

en named. I have diligently tried to work out some plan whereby we could work under one law and all the states share alike.

State Laws Will Remain in Force

If we have a national law, it is quite evident that the state laws will remain in force, but it is possible that the secretary of agriculture conduct the inspection of nurseries through the present state officials, thus allowing only one inspection of our nurseries, which is desirable; on the other hand, it is not desirable that we have two inspections by separate parties.

A Meeting of the Committee

I attended the meeting of the American Association of Horticultural Inspectors and Economic Entomologists held in Chicago December 27 and 28, 1907. Before going to the meeting I sent out eighty-eight letters to the largest growers of nursery stock in the association and received sixty replies, the majority of which favored a national law.

You are all familiar with the resolutions passed by the inspectors and entomologists, which have been published by the trade papers.

[See pages 3-4 and 222-23 of the February and June issues of the JOURNAL for copies of these resolutions. ED.]

The Nurseryman's Side

I said, "The nurserymen are anxious to coöperate with you in combating, controlling and stamping out, if possible, the insect pests and diseases which are liable to be found in the nursery. We realize that it is our duty to our customers and to the man in authority who issues the certificate that they be placed in the proper light with each other and with the grower in issuing the certificate from one state to another. Yet it does seem to us that more stress should be laid by the inspectors upon neglected orchards near a nursery."

Entomologists

I wish it clearly understood after being with the horticultural inspectors and economic entomologists twice at different meetings, I find they are a class of high grade men and are endeavoring to the best of their ability to bring about uniformity in their inspection work. They have their troubles as well as the nurserymen and are trying to solve the problem now before us.

On my return from Chicago, I found several letters from influential nurserymen denouncing most emphatically that any action should be taken without further consideration and presenting the whole matter before the nurserymen at this meeting. I consulted several leading nurserymen and their advice was that every member of the association should be heard.

On May 12 I sent out four hundred and sixty letters and have received replies from two hundred and twenty-five, of which one hundred and seventy have asked for a national or uniform law; twelve against and five neutral.

Of the entomologists or inspectors, thirty-one are favorable and two are opposed.

While many want a uniform law, they want only one law and some do not want a national law. But few who ask for a national law offer any suggestions.

I will give you a few hints from some of the letters received.

From Nurserymen Who Favor

"I have for years thought that there ought to be inspectors at every port of entry to the United States. Of course they could not carefully inspect the contents of every case unless there were strong suspicions, but think they could do a great deal to awaken people elsewhere.

"Then I believe there should be other inspectors to inspect the stock at the nurseryman's place before it is distributed all over the country. Just think what a benefit it would have been to the country if there had been such an inspector in California before the scale was carried all over the country."

Another says: "I favor a national uniform inspection law. I think the gains would be impartiality and uniformity of inspection. This, I think, would soon bring about a modification of the practices in different states, rendering it easier and safer to do interstate nursery business."

Another writes: "I favor a national law because this will place all nurserymen upon an equal basis and do away with the endless delays and troubles on account of the various state laws."

Against a National Inspection Law

Another says: "If national inspection is desired it should include not only nurseries, but orchards, and compel all to keep clear of all kinds of pests."

Another says: "We favor a law that would be equally as stringent upon the fruit grower as well as the nurserymen and all others who own trees of any kind."

Another says: "The writer has recently had a hearing in Washington in regard to a proposed seed law and is none too strong for legislating any industry into federal restrictions or penitentiary penalties and bureaus. The only use for a national law is as a guide for state laws and if it is to be such, the same should be most conservatively and carefully considered. Every person interested commercially should be given an opportunity to be heard.

"The present idea of pernicious activity in federal legislation which will soon put every business man in many unprotected and defenseless industries into the position of working under the possibilities of a prison sentence is not an ideal occupation, in my judgment, for our congressmen."

Another: "We certainly are not in favor of the nurserymen spending any time or money in trying to procure a national uniform inspection law. Congress has no power whatever to change the different state laws and all shipments made would be subject to the different state laws just as soon as they crossed the state line.

"If we could have had a national law passed years ago before all the states had passed their own different laws, we think it would have been a good thing, but so far as we can now see, it would be simply putting one more burden upon the shippers with no corresponding benefits. We would simply have the provision of a national law to comply with in addition to the provision of every state into which we may be shipping.

"We do not know that we have any objection to a national uniform law only as stated above and we should be very much afraid that there would not be an appropriation made so that all nurserymen could have their nurseries inspected.

"We think at the stage to which the matter has now arrived, it would be a

ood deal better to devote our energies to getting the state laws somewhat more uniform than to try to have a national bill passed."

Another says: "There are some 'IFS' in it.

"If all state laws were abolished or amended to conform to the national law, that would be all right, but they will not amend or abolish because that would be looked on as interference with that time-honored proposition of state rights.'

"If we could have a good national law to cover the whole business and all state laws out of the way, it would be a great gain, but as it appears to me, it would make further complications just now to try to have a national bill passed. We might have a national law to cover importations from foreign countries, provided it could be made to harmonize with the present state laws. As the matter stands, I do not feel that there is much to gain in the proposed legislation."

SUMMING UP THE WHOLE MATTER: The last letter puts it in a nutshell and it is now for you to decide—

First: If all state laws were abolished or amended to conform to a national law, that would be all right.

Second: They will not amend or abolish.

Third: What are we to gain by adding another law?

Fourth: Will it help the entomologists and inspectors ir
cient work or help the fruit-growers by adding another inspection?

I want to say I have given this some little time and quite a good deal of thought, and, after doing so, I would recommend that a resolution looking forward to making some definite arrangement for inspecting imported stock be adopted. But further than that I have no recommendation to make other than that based on the report.

ORLANDO HARRISON,
Committee on National Inspection Law.

The members of the visiting committee were then called upon for remarks. The purpose of the resolution which had previously been endorsed by the Association of Economic Entomologists and the Association of Horticultural Inspectors was fully explained and national legislation was pointed out as the best method of bringing about uniform regulations and practice in the inspection for stock received from foreign countries or for stock passing into interstate commerce. A motion was made and seconded that the report be accepted and, after a general discussion of the matter in which several nurserymen expressed their opinion that any national legislation was undesirable, it was passed unanimously.

At the afternoon session a resolution was offered by Mr. Kelsey of New York which was unanimously adopted and is as follows:

Resolved, That the vice-president of each state be and hereby is authorized on behalf of this association to use all reasonable endeavor to have any drastic legislation now in force in his state modified to conform to the laws of other states, the practical workings of which have not entailed undue hardship to the nurserymen or fruit-growers in their execution of such laws.

Resolved, That we heartily express our appreciation of the efforts ma[de] by the economic entomologists and horticultural inspectors of the country [in] their coöperation toward improving the insect pest legislation.

At the morning session, Thursday, the following resolution was pr[e]sented by Mr. Hale of Tennessee which was designed to carry in[to] effect the report which was adopted on the preceding day:

Resolved, That the American Association of Nurserymen in convention as-sembled do hereby endorse the passage of a law by Congress providing for the government inspection of all imports as follows:

SECTION 1. That it shall be the duty of the secretary of agriculture and he is hereby authorized and directed to prepare and promulgate rules and regulations governing importations of any trees, plants, shrubs, vines, grafts, cuttings and buds, commonly known as nursery stock, liable to harbor insect pests or plant diseases either by inspection by competent government employes of the United States Department of Agriculture, or by proper certification from officers of the nation or state from which such shipments were made, provided the same are accepted by the secretary of agriculture. When any such aforesaid nursery stock is offered for entry during the dormant season at any port in the United States, it shall be the duty of the secretary of agriculture, with the approval of the secretary of the treasury, to promulgate rules and regulations governing the inspection of said nursery stock at its destination. All nursery stock imported in accordance with the aforesaid regulations shall be free from all further inspection, quarantine or restrictions in interstate commerce; *provided, however*, that nothing herein contained shall prevent the inspection of such nursery stock by the authorized inspectors of any state or territory or the District of Columbia at the point of destination in accordance with the laws of said state or territory; and that sufficient appropriation be made by congress for this purpose.

Resolved further, That the committee on legislation of this association is hereby instructed to coöperate with the entomologists and inspectors in urging immediate action by congress.

This brought about a general discussion, several members taking the ground that the whole matter had been disposed of by the action taken on the previous day. Mr. Kelsey rose to a point of order and stated that it was his understanding that this was the case. President Hill ruled that the resolution submitted was in order, and, after a brief debate, it was referred to Mr. Pitkin of New York, who is the Legislative Committee of the Nurserymen's Association. No further report on the matter was presented to the meeting by the Legislative Committee at the remaining sessions.

Respectfully submitted,

THOMAS B. SYMONS,

A. F. BURGESS,

Members of Committee.

NOTES ON THE WORK AGAINST THE GYPSY MOTH

By E. P. FELT, *Albany, N. Y.*

The writer had the pleasure recently of spending several days examining the work against the gypsy moth. It is very gratifying, indeed, to state that there has been a marked gain all along the line. By far the greater part of the residential area is in most excellent condition, and while large tracts of woodland are badly infested and, in some instances at least, have been defoliated by the caterpillars, substantial progress is being made, particularly in methods of fighting the insect under such adverse conditions.

Entomologists will be specially interested in recent developments in spraying. The capacity of a spray outfit has been greatly enlarged by replacing the usual six-horse power gasoline engine weighing some 1,800 pounds, by a ten-horse power engine made especially for automobiles and weighing only 400 pounds. Though a heavier and more powerful pump is employed the whole outfit weighs no more than usual. The machinery is mounted upon a stout wagon with a 400-gallon tank. A heavy inch and a half hose, some 400 to 800 feet long with a smooth ¼-inch nozzle is used for work in the woodlands, and a pressure of 200 to 250 pounds maintained. The hose is handled much as though a fire was in progress. Ten men, at intervals of six or eight feet, carry the end of the line, the nozzle being in charge of a superior man, with instructions to keep it moving all the time. The pressure is sufficient to throw the insecticide forty to fifty feet, and the resistance of the air, breaking it into a fine spray, results in the foliage being well covered if the nozzle is handled intelligently. This large apparatus usually requires four horses and is capable of spraying 14 to 16 acres a day at a cost of about $10.20 per acre where the woodland is fairly clear of underbrush. An interesting modification is used for spraying along road sides. It simply consists of a giant extension nozzle mounted on a universal joint, so that the tip may be elevated forty or fifty feet from the ground. This latter is capable of covering a strip 400 feet wide if the wind be favorable.

The work with parasites is particularly interesting. The operations of last year have been greatly extended and a number of extremely valuable improvements made. Messrs. Fiske, Burgess and Townsend have charge, respectively, of the Hymenopterous, Coleopterous and Dipterous parasites. Several Hymenopterous parasites have been bred in large numbers and it is gratifying to state that many Japanese *Apanteles* have been reared upon American caterpillars. Furthermore, a new egg parasite of the gypsy moth has been received from

both Japan and Russia. Mr. Fiske is also working with an interesting egg parasite of the elm leaf beetle. The Coleoptera are receiving the undivided attention of Mr. Burgess. A recent communication has informed the writer that 1,200 larvæ of *Calosoma sycophanta* have been liberated. The work of Mr. Townsend with Tachina flies promises to give some exceedingly interesting results in the near future, particularly as he is now able to recognize the various imported species in any stage. These three gentlemen have an abundance of assistance and we look forward to most important developments within the next two or three years.

The efficiency of the laboratory and the comfort of the staff connected therewith, has been materially increased by the construction of several temporary insectaries or vivaria. One, in particular, is made of 2 x 4 scantling with nothing but a canvas roof and the sides closely covered with fine wire mosquito netting. This gives an abundance of room for breeding at a very slight cost. A larger building, devoted mostly to the breeding of Hymenopterous parasites, has a wooden roof covered with tarred paper and rough boarded sides, and, while admirably adapted for its purposes, is somewhat close and uncomfortable for work, being in this respect far inferior to the more temporary structure described above. Entomologists would get many useful hints from an inspection of this work, and we hope that in the near future some of the more interesting departures will be described in fuller detail.

White-Marked Tussock Moth

Hemerocampa leucostigma Sm. & Abb. This well known pest has caused extensive injuries to horsechestnuts in particular, in Brooklyn, New York, Albany, Troy, Utica, Syracuse, Rochester and Buffalo, the first and the last named cities probably suffering the greatest injury. This species has excited great interest in the fruit section of western New York by eating holes in young fruit much as do green fruit worms, *Xylina* sp., as high as 50% of the fruit being reported damaged in one instance.

Bag Worm

Thyridopteryx ephemeræformis Haw. New York City and its vicinity represents about the northern extension of this species, as a rule. It was somewhat surprising, therefore, to receive healthy larvæ from Germantown, only about forty miles south of Albany. Mr. T. F. Niles, who sent in the specimens, states that no young trees have been set in this locality within the past two years, nearer than a quarter of a mile, consequently it would seem as though the species was able, under certain conditions, to maintain itself considerably farther north than has heretofore been supposed possible.

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OURNAL OF ECONOMIC ENTOMOLOGY

FFICIAL ORGAN OF THE ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

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The editors will thankfully receive news items and other matter likely to be of interest to subscribers. Papers will be published, so far as possible, in the order of reception. All extended contributions, at least, should be in the hands of the editor the first of the month preceding publication. Reprints of contributions may be obtained at cost. Minor line figures will be reproduced without charge, but the engraving of larger illustrations must be borne by contributors or the electrotypes supplied. The receipt of all papers will be acknowledged.—Eds.

It is desirable at this time to once more call the attention of our readers to the fact that most of the matter for the October and December issues should come from working entomologists, not only in this country but also abroad. Our pages are open to all thoughtful contributions along economic lines. Our readers are deeply interested in special problems such as those presented by the gypsy moth work in Massachusetts, and particularly in that phase of the work relating to the introduction of beneficial parasites. New and improved methods are likewise of great importance, and the peculiar conditions governing entomological investigations in various portions of this country and even in foreign countries, are of great interest.

We wish to call the attention of our readers to the desirability of making public short notes of general scientific interest. There must be in the office files of most official entomologists throughout the country, items of this character. They are inaccessible at present and, under ordinary conditions, must remain so unless made public through some such medium as the Journal. A large number of such records, even though each relate to an apparently minor fact, would be of inestimable value and would do much toward making this publication indispensable to working entomologists. We all know, from previous experience, how extremely valuable the seven volumes of *Insect Life* have been, and in not a few instances much of this is due to the abundance of comparatively insignificant notes. One record calls to mind another and it is our expectation that the Journal will eventually become a storehouse for an extremely large number of facts covering every aspect of applied or economic entomology. The department of scientific notes should be a strong one in the October and December issues at least.

The program of the last few meetings of the Association of Eco-

nomic Entomologists has been exceptionally full, and we trust that this JOURNAL may become an agent in ameliorating the congestion. The value of the meetings lies not so much in the amount of information conveyed, as in the discussion of methods and results. There has been, in recent years, an increasingly large number of papers which might be grouped under the general head: Notes for the Year. There seems to be no particular reason why certain of these, at least, could not appear in either the October or December issues, thus reducing to a considerable extent the amount of matter awaiting publication early in January. We would therefore suggest that all writers contemplating preparing papers of this character for the coming meeting, bear this in mind and consider the advisability of submitting the same for publication prior to the annual session. There is no reason why individuals might not elect to do so, and there would be an advantage if this were generally done, since other workers could study the papers and be prepared to discuss the same at some designated period during the regular session. We see no objection to the extension of this practice to important contributions respecting insects or groups of insects or decided modifications in methods of work, particularly as there is a most obvious advantage in allowing an opportunity for careful study before a discussion. We believe that some such change in policy, which latter can be readily brought about by individual initiative, would result in marked benefits to all.

Current Notes

Conducted by the Associate Editor

At the last session of the Nebraska Legislature a law was passed establishing a state Insect Pest and Plant Disease Bureau, which under the provisions of the bill began activity on July 5, 1907. The work of the Bureau is carried on under the joint direction of the State Entomologist and the State Botanist, and for its maintenance the sum of $7,500 for the biennium was appropriated. The working staff of the entomology division is as follows: Lawrence Bruner, Chief of the Division and State Entomologist; Myron H. Swenk, Assistant Entomologist; Harry S. Smith, Assistant State Entomologist; R. W. Dawson, C. H. Gable and J. T. Zimmer, Laboratory Assistants in Entomology. An insectary and greenhouse costing $3,000 has been built on the grounds of the Experiment Station for the experimental work of the Bureau. The purpose of the Bureau as set forth in the bill, is for the "investigation, control and extermination of insect pests and plant diseases through traveling experts, field work and laboratory research." When complaint of injury by insect pests is received a member of the staff visits the locality and investigates the trouble, which is discussed and the approved treatment advocated through the local press, or, if the trouble is widespread, through a

circular devoted to the insect. Two circulars and two bulletins have been issued by the Bureau.

At the last meeting of the Board of Trustees of the Massachusetts Agricultural College, Dr. Charles H. Fernald, for many years Professor of Zoölogy and Entomology at that institution, was elected Director of the Graduate School. This appointment comes as a tribute to the work of Dr. Fernald, who has been very active in securing graduate courses at that institution.

Dr. H. J. Franklin, who received the degree of Doctor of Philosophy at the Massachusetts Agricultural College in June, has accepted a position with the Minnesota State Entomologist at St. Anthony Park. He will teach Entomology in the University of Minnesota and conduct investigation work in the Experimental Station.

Mr. W. F. Turner, who received his Bachelor's degree from the department of Entomology at the Massachusetts Agricultural College, has been appointed Assistant to the State Entomologist of Alabama. He will be engaged in investigation work at the Agricultural Experiment Station.

Mr. J. G. Hyslop, who graduated from the same institution in June, has been appointed Assistant in the Bureau of Entomology, Washington, D. C.

Mr. C. C. Gowdy, who graduated in the class of 1908, Massachusetts Agricultural College, has secured a position as Assistant at the Gypsy Moth Parasite Laboratory, Melrose Highlands, Mass.

Mr. H. B. Filer, who graduated from the Massachusetts Agricultural College in 1906, and who since that time has been connected with the Shade Tree Commission in Newark, N. J., has been appointed City Forester of Buffalo, N. Y. He has charge of the shade trees and forestry interests and has been pushing the spray and other operations for the protection of the city trees against injurious insect pests with great vigor. There is need of more men in this line of work, judging from the poor condition of many shade trees in the eastern United States.

Prof. C. W. Howard, Entomologist of the Transvaal, South Africa, has resigned to accept a position with the Portuguese government. His headquarters will be at Delagoa Bay, South Africa.

Dr. F. Silvestri of the Scuola Superiore di Agricoltura at Portici, Italy, a foreign member of this Association, who is spending the summer in this country, recently visited the Gypsy Moth Parasite Laboratory at Melrose Highlands, Mass. Dr. Silvestri will spend considerable time examining entomological collections in the American Museum of Natural History in New York City. He will also visit California and some of the southern states before returning to Italy.

H. J. Quayle, Assistant Professor of Entomology in the University of California, began work July 1, 1908, at the Southern California Pathological Laboratory, Whittier, Cal., and is engaged in the study of some of the insects of the citrus fruits.

Prof. Charles S. Banks, Government Entomologist, Manila, P. I., spent several weeks in this country studying the collections at Washington, New York and Albany. He returns via Europe and will study the collections at the British Museum, Leyden, Brussels, Berlin, Stockholm and Turin. Prof. Banks has been giving particular attention to Culicidæ and has succeeded in rearing some extremely interesting forms.

Prof. C. W. Woodworth, Berkeley, Cal., spent a short time in the East, visiting some of the more important entomological centers.

The entomological course given at the Graduate School of Agriculture held last month at Cornell University, has been well attended, and the entire session has been considered most successful by those responsible for the venture.

The Quebec Society for the Protection of Plants (from insects and fungus pests), was organized at a meeting held June 24 at Macdonald College. This society, as its name indicates, will be strongly of an economic nature. The headquarters for the society will be, for the present, Macdonald College. The following officers were elected for the ensuing year:

President, Prof. W. Lockhead, Macdonald College; Vice-President, Frère Liguori, La Trappe, Oka, P. Q.; Secretary-Treasurer, Douglas Weir, Macdonald College; Curator and Librarian, J. M. Swaine, Macdonald College; Directors, Rev. Dr. Fyles, Levis, P. Q., Rev. G. Ducharme, Rigaud, P. Q., A. F. Winn, Montreal, Auguste Dupuis, Village des Aulnaies, Dr. W. Grignon, Ste Adèle.

A substantial grant has been given the Society by the Quebec Department of Agriculture. As a large number of persons in the Province of Quebec are interested in the study of insects and fungi, it is believed that the new society will have a large membership, and will be able to do a great deal of work in the interests of agriculture.

Economic Entomology at Harvard University.—Replying to an inquiry, Prof. W. M. Wheeler states that during the coming year only two courses will be given; one by himself on the "Structure, Development and Habits of Insects," and one by Mr. Paul Hayhurst, recently appointed instructor, on "Common Economic Insects," both being intended primarily for graduate students. These courses begin February 1, 1909, the first semester being reserved for research work. Provision for the latter, commencing October 1 of the present year, has been made at the Bussey Institution, Forest Hills, Mass., where the entomological laboratories are situated.

Elm Leaf Beetle

Galerucella luteola Mull. The ravages of this pest continue in New York state, the elms of Albany, Troy, Schenectady, Schuylerville, Ithaca and those of some other localities in the Hudson Valley at least, being very badly injured, despite more or less sporadic efforts to control the insect. This species, under favorable conditions, produces two generations annually in the latitude of Albany. The experience of the past ten years has shown that the area of greatest injury in Albany is restricted to the older and more thickly settled fourth of the city. The comparative immunity of other parts of the municipality is probably due to the greater abundance of native birds, and presumably in part to fewer shelters where the beetles can hibernate successfully. This marked restriction was likewise very evident in Schenectady, the ravages of the beetle being particularly marked in the vicinity of an open belfry where the insects undoubtedly hibernated in large numbers.

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